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EDITED BY

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THE YEAR 1928

January

- 1 New Year's Day
- 6 Epiphany—Twelfth Day
- 25 St. Paul's Day

February

- 2 Candlemas Day
- 12 Lincoln's Birthday
- 14 St. Valentine's Day
- 21 Shrove Tuesday
- 22 Ash Wednesday—Lent
- Washington's Birthday

March

- 17 St. Patrick's Day
- 25 Lady Day—Feast of the Annunciation

April

- 1 All Fools' Day
- 5 Jewish Passover
- 6 Good Friday
- International Bird Day
- 15 Easter—Jewish Passover
- 19 Patriots' Day (Mass.)
- 23 St. George's Day
- 25 St. Mark's Day
- Jewish Shevuoth
- 26 Southern Memorial Day

May

- 1 May Day
- 5 Arbor Day—Many States
- 13 Mother's Day
- 17 Ascension—Holy Thursday
- 24 Empire Day (Great Britain)
- 27 Whitsunday—Pentecost
- 30 Memorial Day

June

- 3 Trinity
- 10 Children's Day
- 14 Flag Day
- 24 St. John Baptist Day

July

- 1 Dominion Day (Canada)
- 4 Independence Day
- 15 St. Swithen's Day

August

- 24 St. Bartholomew's Day

September

- 3 Labor Day
- 15 Jewish New Year
- 17 Constitution Day
- 24 Jewish Yom Kippur
- 29 Jewish Succoth
- 30 Michaelmas

October

- 12 Columbus Day
- 18 St. Luke's Day
- 27 Navy Day—Roosevelt's Birthday
- 31 All Hallowe'en

November

- 1 All Saints' Day
- 6 Election Day
- 11 Armistice Day
- 29 Thanksgiving Day
- 30 St. Andrew's Day

December

- 6 St. Nicholas Day
- 21 St. Thomas Day
- Forefather's Day
- 25 Christmas
- 28 Childermas—Holy Innocents



MOON'S PHASES						Sun on Meridian		MOON'S PLACE	CALENDAR for			CALENDAR for			Moon's Southing or Meridian Passage	
Eastern Time			Central Time			Civil Time			New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.				
D.	H.	M.	D.	H.	M.	D.	H. M. S.		Sun rises	Sun sets	Moon sets	Sun rises	Sun sets	Moon sets		
H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.		H.M.	H.M.	H.M.	H.M.	H.M.	H.M.		
☉	7	1	8M	7	0	8M	1 12 3 19									
☾	14	4	14E	14	3	14E	11 12 7 44									
☾	22	3	19E	22	2	19E	21 12 11 14									
☾	29	2	26E	29	1	26E	28 12 12 57									
Day Astronomy, Church Days, etc.								C.			H.M. H.M. H.M.			H.M. H.M. H.M.		
1. 1st Sunday after Christmas								Length of Day 9h 23m—of Twilight 1h 39m								
1	Su	Circ. New Year's Day					M	☾	7 39	4 29	49	7 22	4 45	48	7 18	
2	M	☾ sets 6-8 eve.					M	☾	7 39	4 30	2 3	7 22	4 46	2 1	8 10	
3	Tu	☾ Perigee					M	☾	7 39	4 31	3 20	7 22	4 47	3 15	9 5	
4	W	☉ nearest sun						☉	7 38	4 32	4 38	7 22	4 48	4 31	10 3	
5	Th	12th night					☾	☾	7 38	4 33	5 55	7 22	4 49	5 47	11 4	
6	Fr	Epiphany—12th day					☾	☾	7 38	4 34	rises	7 22	4 50	rises	morn.	
7	Sa	Orion rises 4-6 eve.					☾	☾	7 38	4 35	5 2	7 22	4 50	5 11	5	
2. 1st Sunday after Epiphany								Length of Day 9h 29m—of Twilight 1h 38m								
8	Su	☾ sets 2-4 mo.					☾	☉	7 38	4 36	6 11	7 22	4 51	6 19	1 4	
9	M	☾ merid. 6-8 eve. Supr. ☉ ☾					☉	☉	7 38	4 37	7 19	7 22	4 52	7 25	2 0	
10	Tu	☉ merid. 1-3 mo. ☉ ☾					☉	☉	7 37	4 38	8 27	7 22	4 54	8 31	2 51	
11	W	☾ sets 5-7 eve.					☾	☉	7 37	4 39	9 32	7 22	4 55	9 35	3 38	
12	Th	Capella merid. 10:28 eve.					☾	☉	7 37	4 40	10 36	7 22	4 56	10 37	4 22	
13	Fr	Arbor Day, La.					☾	☉	7 36	4 42	11 37	7 21	4 57	11 37	5 3	
14	Sa	☉ rises 9-11 eve.					☾	☉	7 36	4 43	morn.	7 21	4 58	morn.	5 44	
3. 2nd Sunday after Epiphany								Length of Day 9h 39m—of Twilight 1h 37m								
15	Su	Moon Apogee					☾	☉	7 35	4 44	38	7 20	4 59	36	6 24	
16	M	☉ 28' N. of ☾					☾	☉	7 35	4 45	1 39	7 20	5 0	1 35	7 6	
17	Tu	Pleiades merid. 7:40 eve.					☾	☉	7 34	4 46	2 41	7 20	5 1	2 35	7 50	
18	W	Hyades mer. 8:40 eve.					M	☉	7 34	4 48	3 45	7 19	5 2	3 38	8 36	
19	Th	Gen. Lee's birthday					☉	☉	7 33	4 49	4 48	7 19	5 3	4 40	9 25	
20	Fr	(19th) ☾ 1° N. of ☉ ☾ 2° N. of ☉					☉	☉	7 32	4 50	5 51	7 18	5 4	5 42	10 18	
21	Sa	(20th) ☉ 40' N. of ☉					☉	☉	7 31	4 52	6 49	7 18	5 6	6 39	11 13	
4. 3rd Sunday after Epiphany								Length of Day 9h 50m—of Twilight 1h 36m								
22	Su	Algol mer. 6:56 eve.					☾	☉	7 31	4 53	sets	7 17	5 7	sets	ev. 8	
23	M	☉ mer. 11 ev. ☉ 23'S. of ☉ ☉ ☾					☉	☉	7 30	4 55	5 47	7 16	5 8	5 55	1 3	
24	Tu	Orion mer. 9 eve.					☾	☉	7 29	4 56	7 0	7 16	5 9	7 6	1 56	
25	W	Conversion of St. Paul					☾	☉	7 28	4 57	8 13	7 15	5 10	8 17	2 48	
26	Th	Aldebaran mer. 8:24 eve. ☉ ☉					☉	☉	7 27	4 59	9 26	7 14	5 12	9 28	3 38	
27	Fr	El Nath mer. 8:56 eve. ☉ ☉					☉	☉	7 26	5 0	10 39	7 14	5 13	10 39	4 26	
28	Sa	Mira mer. 5:40 eve					☉	☉	7 25	5 2	11 53	7 13	5 14	11 51	5 16	
5. 4th Sunday after Epiphany								Length of Day 10h 4m—of Twilight 1h 35m								
29	Su	Moon Perigee. McKinley's b'day					☾	☉	7 24	5 3	morn.	7 12	5 16	morn.	6 6	
30	M	Cetus mer. 4-7 eve.					☉	☉	7 23	5 4	1 9	7 11	5 16	1 5	6 59	
31	Tu	Sirius mer. 10 eve.					☉	☉	7 22	5 6	2 24	7 10	5 17	2 18	7 54	

Second
Month

February

Twenty-
nine
Days

MOON'S PHASES				Sun on Meridian		MOON'S PLACE	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			CALENDAR for N. J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's Southing or Meridian Passage
Eastern Time		Central Time		Civil Time			Sun rises	Sun sets	Moon sets	Sun rises	Sun sets	Moon sets	
D. H. M.	D. H. M.	D. H. M.	D. H. M.	D. H. M. S.									
☾	5 3 11E	5 2 11E	1 12 13 38										
☾	13 2 5E	13 1 5E	11 12 14 22										
☾	21 4 41M	21 3 41M	21 12 13 51										
☾	27 10 21E	27 9 21E	28 12 12 50										
Day Astronomy, Church Days, etc.						C.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.
1W	Orion mer. 8-9 eve.					☾	7 21	5 7	3 40	7 9	5 19	3 32	8 52
2Th	Purification, Gd. Hog Day ☾					☾	7 20	5 9	4 51	7 8	5 20	4 42	9 53
3Fr	Pres. Wilson died '24 M					☾	7 18	5 10	5 56	7 7	5 21	5 46	10 50
4Sa	♂ in mer. 7-9 eve.					☾	7 17	5 12	6 50	7 6	5 22	6 40	11 47
6. Septuagesima Sunday Length of Day 10h 18m—of Twilight 1h 34m													
5Su	Dog Star mer. 9:44 eve.					☾	7 16	5 13	rises	7 5	5 23	rises	morn.
6M	Procyon mer. 9:52 eve. ♂ ♀					☾	7 15	5 14	6 9	7 4	5 25	6 15	1 40
7Tu	☾ in mer. 11 eve.-1 mo. M					☾	7 13	5 16	7 15	7 3	5 26	7 19	1 29
8W	Denebola rises 7:37 eve.					☾	7 12	5 17	8 20	7 2	5 27	8 22	2 14
9Th	Roosevelt Mem. Day. § Gr. El. E					☾	7 11	5 19	9 24	7 1	5 28	9 24	2 57
10Fr	Cervus rises 10 eve. § Per.					☾	7 9	5 20	10 24	7 0	5 29	10 23	3 38
11Sa	The Kids mer. 7 eve.					☾	7 8	5 22	11 26	6 59	5 31	11 23	4 19
7. Sexagesima Sunday Length of Day 10h 34m—of Twilight 1h 28m													
12Su	Lincoln's Birthday. Moon apogee					☾	7 6	5 23	morn.	6 58	5 32	morn.	5 0
13M	Lyra overhead, lat. 40° + 9 eve.					☾	7 5	5 24	27	6 56	5 33	23	5 43
14Tu	St. Valentine's D. ♀ 1° 21' N. of ♂					☾	7 4	5 26	1 31	6 53	5 34	1 25	6 28
15W	Capella mer. 7 eve. b 1° 44' N. of ♂					☾	7 2	5 27	2 34	6 54	5 35	2 26	7 15
16Th	Regulus mer. 0:22 mo.					☾	7 1	5 29	3 38	6 53	5 36	3 29	8 6
17Fr	Sickle mer. 12 eve.-1 mo.					☾	6 59	5 30	4 36	6 51	5 38	4 26	8 59
18Sa	♀ 3° 32' N. of ♂. ♂ 2° 12' N. of ♀					☾	6 57	5 31	5 30	6 50	5 39	5 20	9 54
8. Quinquagesima Sunday Length of Day 10h 51m—of Twilight 1h 23m													
19Su	Castor mer. 9:33 eve. M					☾	6 56	5 33	6 17	6 49	5 40	6 8	10 50
20M	Algol mer. 5 eve.					☾	6 54	5 34	6 57	6 47	5 41	6 49	11 45
21Tu	Shrove Tuesday, Mardi Gras Fla. La. and Texas.					☾	6 53	5 36	sets	6 46	5 42	sets	ev. 38
22W	Ash Wed., Beg. Arbor D. Ala., N. Dak. and Texas.					☾	6 51	5 37	7 10	6 44	5 43	7 13	1 30
23Th	(22) Washington's B. 24° N. of ♂					☾	6 49	5 38	8 27	6 43	5 44	8 27	2 21
24Fr	St. Matthias, Moon Per. ♂ § ☾					☾	6 48	5 40	9 42	6 42	5 46	9 40	3 11
25Sa	Pollux mer. 9:16 eve.					☾	6 46	5 41	10 59	6 40	5 47	10 55	4 2
9. 1st Sunday in Lent Length of Day 11h 9m—of Twilight 1h 30m													
26Su	Quadragesima Sun.					☾	6 44	5 43	morn.	6 39	5 48	morn.	4 55
27M	Longfellow's birthday					☾	6 43	5 44	3	6 37	5 49	6	5 50
28Tu	♂ mer. 2-4 mo.					☾	6 42	5 45	1 32	6 36	5 50	1 24	6 47
29W	Ember Day					☾	6 41	5 46	2 44	6 35	5 50	2 34	7 45

Third
Month

March

Thirty-one
Days

MOON'S PHASES						Sun on Meridian			MOON'S PLACE	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			CALENDAR for N. J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's Southern or Meridian Passage											
Eastern Time			Central Time			Civil Time				Sun rises	Sun sets	Moon sets	Sun rises	Sun sets	Moon sets												
D.	H.	M.	D.	H.	M.	D.	H.	M.									H.M.	H.M.	H.M.	H.M.	H.M.	H.M.					
☾	6	6	27M	6	5	27M	1	12	12	27	☾	6	39	5	47	3	50	6	34	5	51	3	37	8	43		
☾	14	10	20M	14	9	20M	11	12	10	6	☾	6	37	5	48	4	45	6	33	5	52	4	36	9	39		
☾	21	3	29E	21	2	29E	21	12	7	14	☾	6	36	5	49	5	31	6	32	5	53	5	23	10	32		
☾	28	6	54M	28	5	54M	28	12	5	7	☾	C. H.M. H.M. H.M.			H.M. H.M. H.M.			H.M. H.M. H.M.			H.M. H.M. H.M.						
Day Astronomy, Church Days, etc.																											
1	Th	St. David					☾	☾	6	39	5	47	3	50	6	34	5	51	3	37	8	43					
2	Fr	Ember Day					M	☾	6	37	5	48	4	45	6	33	5	52	4	36	9	39					
3	Sa	Ember Day					☾	☾	6	36	5	49	5	31	6	32	5	53	5	23	10	32					
10. 2nd Sunday in Lent Length of Day 11h 25m—of Twilight 1h 29m																											
4	Su	☾ sets 4-5 mo.					♊	☾	6	34	5	51	6	8	6	30	5	55	6	0	11	22					
5	M	Arbor Day, Ark.					♋	☾	6	32	5	52	rises	6	28	5	56	rises	morn.								
6	Tu	Gt. Cross overhead 9 eve.					♌	☾	6	30	5	53	6	6	6	27	5	57	6	9	8						
7	W	Arbor Day, Calif.					♍	☾	6	28	5	55	7	10	6	25	5	58	7	12	52						
8	Th	♈ rises 10-12 eve.					♎	☾	6	27	5	56	8	12	6	24	5	59	8	12	1	34					
9	Fr	Orion mer. 6-7 eve. ☐ ♄ ⊙ W					♏	☾	6	25	5	57	9	14	6	22	6	0	9	12	2	15					
10	Sa	Regulus mer. 10:46 eve.					♐	☾	6	23	5	59	10	16	6	21	6	1	10	11	2	56					
11. 3rd Sunday in Lent Length of Day 11h 44m—of Twilight 1h 30m																											
11	Su	Moon Apogee					♑	☾	6	21	6	0	11	19	6	18	6	2	11	13	3	38					
12	M	♈ in mer. 1-3 mo.					♒	☾	6	19	6	1	morn.	6	16	6	3	morn.	4	21							
13	Tu	☾ sets 8-10 eve.					♓	☾	6	18	6	3	17	6	14	6	4	10	5	7							
14	W	Hercules mer. 10 eve. ♄ 2°N. ☾ ☾					♑	☾	6	16	6	4	1	18	6	13	6	5	1	10	5	56					
15	Th	Procyon mer. 7:40 eve. ♄ in Per					♈	☾	6	14	6	5	2	25	6	11	6	6	2	15	6	48					
16	Fr	Sirius mer. 7:8 eve.					♉	☾	6	12	6	6	3	20	6	10	6	7	3	10	7	41					
17	Sa	St. Patrick's Day. ☾ 36' N. of ♈					♊	☾	6	10	6	8	4	8	6	8	6	8	3	59	8	35					
12. 4th Sunday in Lent. Mid Lent Length of Day 12h 3m—of Twilight 1h 31m																											
18	Su	Mid Lent Sunday ☾ 3° N. of ☾					♋	☾	6	8	6	9	4	51	6	6	6	9	4	43	9	30					
19	M	♀ ☾ ☾ ☾ ☾ } Days and nights equal					♌	☾	6	6	6	10	5	27	6	5	6	10	5	21	10	24					
20	Tu	☾ enters ♈, spring beg.					♍	☾	6	4	6	12	5	58	6	3	6	11	5	54	11	16					
21	W	Sickle mer. 10-11 eve. ☾ ☾					♎	☾	6	3	6	13	sets	6	2	6	12	sets	ev. 8								
22	Th	♈ Gr. Elong. W. of ☾ ☾ ☾					♏	☾	6	1	6	14	7	19	6	1	6	13	7	19	1	0					
23	Fr	Moon Perigee					♐	☾	5	59	6	16	8	38	6	0	6	14	8	35	1	52					
24	Sa	☾ mer. 6-8 eve. ☾ ☾ ☾					☾	☾	5	57	6	17	9	59	5	58	6	15	9	54	2	46					
13. 5th Sunday in Lent Length of Day 12h 19m—of Twilight 1h 32m																											
25	Su	Annunciation, Lady D. ♄ in Ap.					☾	☾	5	55	6	18	11	19	5	57	6	16	11	11	3	42					
26	M	Arcturus mer. 2:12 mo.					☾	☾	5	53	6	19	morn.	5	55	6	17	morn.	4	40							
27	Tu	Hyades set 11 eve.					☾	☾	5	51	6	21	35	5	53	6	18	26	5	40							
28	W	Castor mer. 7:8 eve.					☾	☾	5	50	6	22	1	45	5	52	6	19	1	35	6	39					
29	Th	Sirius sets 11:15 eve.					☾	☾	5	48	6	23	2	44	5	50	6	20	2	34	7	36					
30	Fr	☾ in mer. 7:30-9:30 eve. ♄ in Ap					☾	☾	5	46	6	24	3	32	5	48	6	22	3	23	8	29					
31	Sa	Pollux mer. 6:40 eve.					☾	☾	5	44	6	26	4	11	5	46	6	23	4	3	9	19					

Fourth
Month



April

Thirty
Days

MOON'S PHASES				Sun on Meridian		MOON'S PLACE	CALENDAR for			CALENDAR for			Moon's Southing or Meridian Passage		
Eastern Time		Central Time		Civil Time			New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.					
D.	H. M.	D.	H. M.	D.	H. M. S.		Sun rises	Sun sets	Moon sets	Sun rises	Sun sets	Moon sets			
☉	4 10 38E	4 9 38E	1 12 3 54	☾	13 3 9M		13 2 9M	11 12 1 2	☾	20 0 25M	19 11 25E	21 11 58 40		☾	26 4 42E
Day	Astronomy, Church Days, etc.					C.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.		
14. Palm Sunday Length of Day 12h 40m—of Twilight 1h 34m															
1 Su	Perseus mer. 8 eve. ♂ ♀					☾	5 42	6 27	4 42	5 45	6 24	4 35	10 6		
2 M	Regulus mer. 9:20 eve.					☾	5 40	6 28	5 9	5 44	6 25	5 5	10 49		
3 Tu	Orion's Belt sets 10 eve.					☾	5 38	6 29	5 30	5 42	6 26	5 28	11 31		
4 W	Pleiades set 10 eve.					☾	5 36	6 31	rises	5 40	6 27	rises	morn.		
5 Th	♄ mer. 5-7 eve.					☾	5 34	6 32	7 4	5 39	6 28	7 2	12		
6 Fr	Good Friday. Arbor Day N. Dak., Ark., Mo.					☾	5 33	6 33	8 5	5 37	6 29	8 2	53		
7 Sa	Moon Apogee (6th) ♂ ♀					☾	5 31	6 34	9 8	5 36	6 30	9 3	1 35		
15. Easter Sunday Length of Day 12h 57m—of Twilight 1h 35m															
8 Su	♄ sets 1-3 mo. ♀ 1° S. of ♀					☾	5 29	6 36	10 11	5 34	6 31	10 4	2 18		
9 M	Arcturus mer. 5:28 eve.					☾	5 27	6 37	11 14	5 32	6 32	11 6	3 3		
10 Tu	♄ ris. 8-10 eve. ♀ 2° N. of ♀					☾	5 25	6 38	morn.	5 31	6 33	morn.	3 50		
11 W	Nor. Crown rises 6-7 eve.					☾	5 24	6 40	15	5 29	6 34	5	4 40		
12 Th	☉ sets 1-3 mo.					☾	5 22	6 41	1 12	5 28	6 35	1 2	5 32		
13 Fr	Arbor D. W. Va., Md., Or., N. J. ♂ ♀					☾	5 20	6 42	2 3	5 26	6 36	1 53	6 25		
14 Sa	(13) Jefferson's birthday					☾	5 18	6 43	2 47	5 25	6 37	2 38	7 18		
16. Low Sunday Length of Day 13h 15m—of Twilight 1h 36m															
15 Su	♄ mer. 4-6 eve. ♀ 1° S. of ♂					☾	5 16	6 45	3 24	5 23	6 38	3 16	8 10		
16 M	☉ mer. 7-9 eve. ♂ ♀					☾	5 15	6 46	3 57	5 22	6 39	3 51	9 1		
17 Tu	Aldebaran sets 9:48 eve.					☾	5 14	6 47	4 24	5 20	6 40	4 21	9 53		
18 W	♄ mer. 10-12 ev. ♂ ♀ ♂ ♂					☾	5 11	6 48	4 51	5 19	6 41	4 49	10 44		
19 Th	Patriots' Day (Mass.) ♂ ♀					☾	5 10	6 50	5 18	5 17	6 42	5 18	11 37		
20 Fr	Moon Per. Arb. D. Utah, Ariz., Ind. M					☾	5 8	6 51	sets	5 16	6 43	sets	ev. 31		
21 Sa	♄ rises 8-10 eve. M					☾	5 6	6 52	8 54	5 14	6 44	8 48	1 27		
17. 2nd Sunday after Easter Length of Day 13h 32m—of Twilight 1h 37m															
22 Su	Arbor Day Neb. ♂ ♀					☾	5 4	6 53	10 15	5 13	6 45	10 7	2 27		
23 M	St. George					☾	5 3	6 55	11 32	5 12	6 46	11 22	3 28		
24 Tu	Sickle mer. 8 eve.					☾	5 1	6 56	morn.	5 10	6 47	morn.	4 30		
25 W	St. Mark					☾	5 0	6 57	37	5 9	6 48	27	5 29		
26 Th	Southern Memorial Day					☾	4 58	6 58	1 32	5 7	6 49	1 22	6 25		
27 Fr	Grant's birthday					☾	4 56	7 0	2 13	5 6	6 50	2 5	7 17		
28 Sa	Arbor Day, Mass. ♂ ♀					☾	4 55	7 1	2 47	5 5	6 51	2 40	8 5		
18. 3rd Sunday after Easter Length of Day 13h 49m—of Twilight 1h 44m															
29 Su	Arbot Day, Mich. ♀ 26° S. of ♀					☾	4 53	7 2	3 14	5 3	6 52	3 10	8 49		
30 M	Orion sets 8-10 eve.					☾	4 52	7 3	3 37	5 2	6 53	3 34	9 31		



MOON'S PHASES										CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.										CALENDAR for N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.										Moon's Position or Meridian Passage																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
Eastern Time					Central Time					Sun on Meridian Civil Time					Sun rises					Sun sets					Moon sets					Moon rises					Moon sets					Moon rises					Moon sets																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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☾	4	3	12	E	4	2	12	E	1	11	57	1	4	51	7	5	3	58	5	1	6	54	3	56	10	12	10	12	4	49	7	6	4	19	5	0	6	55	4	19	10	52	10	52	4	47	7	7	4	38	4	58	6	56	4	40	11	33	11	33	4	46	7	8	rises	4	57	6	57	rises	morn.	4	44	7	10	8	3	4	56	6	58	7	56	10	55	10	55																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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☾	26	4	12	E	26	3	12	E	28	11	57	7	4	44	7	10	8	3	4	56	6	58	7	56	10	55	10	55																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
Day	Astronomy, Church Days, etc.															C.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M



MOON'S PHASES						Sun on Meridian	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			CALENDAR for N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's Position or Meridian Passage								
Eastern Time			Central Time			Civil Time	C.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.							
D.	H.	M.	D.	H.	M.	D.									H.	M.	S.				
☾	3	7	13M	3	6	13M									1	11	57	40			
☾	11	0	51M	10	11	51E									11	11	59	27			
☉	17	3	42E	17	2	42E	21	12	1	35											
☾	24	-5	47E	24	4	47E	28	12	2	3E											
Day	Astronomy, Church Days, etc.																				
1Fr	Ember Day. Moon Apogee						=	4	17	7	39	3	27	4	33	7	22	3	32	10	58
2Sa	Emb. Day. Garfield died '82						m	4	16	7	40	3	53	4	33	7	23	3	59	11	44
23. Trinity Sunday										Length of Day 14h 51m—of Twilight 1h 58m											
3Su	Jeff. Davis' b'day. Tot. Ec. ☽ ♀ m						m	4	15	7	40	rises	4	33	7	24	rises	morn.			
4M	♂ in Per. (3) ♀ Gr. El. E. ♂ ♄)						)	4	15	7	41	9	0	4	32	7	24	8	51	32	
5Tu	Cygnus mer. 3-4 mo. ☽ *						*	4	15	7	42	9	55	4	32	7	25	9	45	1	23
6W	♊ sets 10-11 eve. ♂ ♄ ☽						☽	4	14	7	43	10	44	4	32	7	26	10	34	2	15
7Th	Castor sets 10 eve. ☽ ♄						♀	4	14	7	43	11	24	4	31	7	26	11	16	3	7
8Fr	Arcturus mer. 9:4 eve. ♂ ♄						♄	4	14	7	44	11	58	4	31	7	27	11	51	3	59
9Sa	So. + mer. 6-8 eve. =						=	4	14	7	45	morn.	4	31	7	27	morn.	4			49
24. 1st Sunday after Trinity										Length of Day 14h 57m—of Twilight 1h 59m											
10Su	Children's Day =						=	4	13	7	45	28	4	31	7	28	22	5			38
11M	St. Barnabas ☽						☽	4	13	7	46	54	4	30	7	28	50	6			25
12Tu	☽ sets 9-11 eve. ♂ ♄						☽	4	13	7	46	1	18	4	30	7	29	1	16	7	13
13W	♊ mer. 0-2 mo. ♂ ♄						☽	4	12	7	47	1	42	4	30	7	29	1	43	8	2
14Th	Flag Day ☽ ♄						☽	4	11	7	47	2	9	4	30	7	30	2	11	8	54
15Fr	⚡ mer. 7-9 eve. ☽						☽	4	11	7	48	2	38	4	30	7	30	2	42	9	49
16Sa	Moon Perigee ☽						☽	4	11	7	48	3	10	4	30	7	31	3	17	10	48
25. 2nd Sunday after Trinity										Length of Day 15h 1m—of Twilight 2h 0m											
17Su	B'nker Hill D. (Mass.) ☽ Par. Ec. ☽						☽	4	11	7	49	3	55	4	30	7	31	4	3	11	51
18M	☽ sets 10-12 eve. ☽						☽	4	11	7	49	sets	4	30	7	31	sets	ev.			55
19Tu	Regulus sets 11 eve. ☽						☽	4	12	7	50	10	2	4	30	7	32	9	52	1	58
20W	Longest days ☽						☽	4	13	7	50	10	45	4	31	7	32	10	37	2	57
21Th	☽ ent. ☽. Summer begins ☽						☽	4	13	7	50	11	19	4	31	7	32	11	13	3	52
22Fr	Spica mer. 7:20 eve. ☽						☽	4	13	7	50	11	46	4	31	7	32	11	42	4	41
23Sa	Antares mer. 10:24 eve. ☽						☽	4	13	7	50	morn.	4	31	7	32	morn.	5			26
26. 3rd Sunday after Trinity										Length of Day 15h 1m—of Twilight 2h 1m											
24Su	Nat. of John the Bap. Mid-Summer Day ☽						☽	4	14	7	51	9	4	32	7	33	7	6			9
25M	♂ mer. 3-4 mo. ☽						☽	4	14	7	51	29	4	32	7	33	28	6			50
26Tu	☽ rises 8-10 eve. ☽						☽	4	14	7	51	50	4	32	7	33	51	7			30
27W	Fomalhaut rises 12 eve. =						=	4	15	7	51	1	10	4	33	7	33	1	13	8	12
28Th	Moon Apogee (29) ♂ ♀ ☽ ♂ ♄ M						M	4	15	7	50	1	30	4	33	7	33	1	34	8	54
29Fr	Peter & Paul chief Apos. ☽ ☽ ☽						☽	4	16	7	50	1	56	4	33	7	33	2	2	9	40
30Sa	= mer. 8-10 eve. ☽ ♄						☽	4	16	7	50	2	24	4	34	7	33	2	32	10	26

*Moon lowest of the year or about 57° lower than when highest at Full in December.



MOON'S PHASES					Sun on Meridian		MOON'S PLACE	CALENDAR for			CALENDAR for			Moon's Southing or Meridian Passage
Eastern Time		Central Time		Civil Time		New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.					
D.	H. M.	D.	H. M.	D.	H. M. S.	Sun rises		Sun sets	Moon sets	Sun rises	Sun sets	Moon sets	Eve.	
						H.M.		H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	
☾	2 9 48E	2 8 48E	1 12 3 40											
☾	10 7 16M	10 6 16M	11 12 5 19											
☾	16 11 35E	16 10 35E	21 12 6 15											
☾	24 9 38M	24 8 38M	28 12 6 20											
Day					Astronomy, Church Days, etc.									
27. 4th Sunday after Trinity					Length of Day 14h 59m—of Twilight 2h 0m									
1 Su	☿ mer. 5-7 eve. ♂ ♀ ☽				☿ M	☿	4 16	7 50	2 59	4 34	7 33	3 8	11 18	
2 M	☿ of Pegasus rises 9-11 eve.					☿	4 17	7 50	rises	4 35	7 33	rises	morn.	
3 Tu	Dog Days begin. ☿ 18° S. of ☿					☿	4 18	7 50	8 42	4 35	7 32	8 32	10	
4 W	Ind. Day. Pres. Coolidge b. '72					☿	4 18	7 50	9 25	4 36	7 32	9 16	1 3	
5 Th	(4th) ☽ farthest from ☾				M	☿	4 19	7 49	10 2	4 36	7 32	9 54	1 55	
6 Fr	Lyra mer. 11-12 eve.					☿	4 20	7 49	10 31	4 37	7 32	10 25	2 46	
7 Sa	☿ rises 11 eve.-1 mo.					☿	4 20	7 49	10 58	4 38	7 31	10 54	3 35	
28. 5th Sunday after Trinity					Length of Day 14h 53m—of Twilight 1h 59m									
8 Su	Vega mer. 11:30 eve.					☿	4 21	7 48	11 22	4 38	7 31	11 20	4 23	
9 M	☿ mer. 9-11 eve. ♂ ☽				☿	☿	4 22	7 48	11 46	4 39	7 31	11 46	5 10	
10 Tu	Coma Berenice's mer. 5-6 eve.					☿	4 22	7 47	morn.	4 40	7 30	morn.	5 57	
11 W	☽ sets 10-12 eve.					☿	4 23	7 47	9	4 40	7 30	11	6 46	
12 Th	Orangemen's Day. ☿ 1° N. of ☽				☿	☿	4 24	7 46	36	4 41	7 30	40	7 38	
13 Fr	☿ rises 2-4 mo.					☿	4 25	7 46	1 8	4 42	7 29	1 14	8 34	
14 Sa	Moon Perigee				☽	☿	4 26	7 45	1 45	4 42	7 29	1 53	9 34	
29. 6th Sunday after Trinity					Length of Day 14h 45m—of Twilight 1h 56m									
15 Su	St. Swithin's Day				☿	☿	4 27	7 44	2 33	4 43	7 28	2 42	10 36	
16 M	Betelgeuse rises 4 mo.					☿	4 28	7 44	3 29	4 44	7 28	3 40	11 40	
17 Tu	Sickle sets 9 eve. ♂ ♀				☿	☿	4 28	7 43	sets	4 44	7 27	sets	ev. 41	
18 W	Gt. + mer. 12 eve.-1 mo.					☿	4 29	7 42	9 15	4 45	7 26	9 8	1 38	
19 Th	Orion rises 4 mo. ♂ ☽				☿	☿	4 30	7 41	9 46	4 46	7 26	9 40	2 30	
20 Fr	Altair mer. 12 eve. ♀ in Per.					☿	4 31	7 40	10 11	4 47	7 25	10 7	3 18	
21 Sa	Cygnus mer. 1 mo. ☽ Gr. El. W.				☿	☿	4 32	7 39	10 33	4 48	7 24	10 31	4 3	
30. 7th Sunday after Trinity					Length of Day 14h 34m—of Twilight 1h 52m									
22 Su	Mary Magdalen				☿	☿	4 33	7 38	10 53	4 49	7 23	10 53	4 45	
23 M	7-Stars rise 1 mo.					☿	4 34	7 38	11 13	4 49	7 23	11 15	5 26	
24 Tu	Antares sets 1 mo.					☿	4 36	7 36	11 34	4 50	7 22	11 38	6 8	
25 W	St. James					☿	4 37	7 36	11 57	4 51	7 21	morn.	6 50	
26 Th	W. J. Bryan died '25					☿	4 38	7 34	morn.	4 52	7 20		2 7 34	
27 Fr	(26) Moon Apogee					☿	4 39	7 33	24	4 53	7 19	31	8 21	
28 Sa	Aquila mer. 11:30 eve. ♂ ☽ ☿				☿	☿	4 40	7 32	56	4 54	7 18	1 4	9 11	
31. 8th Sunday after Trinity					Length of Day 14h 22m—of Twilight 1h 52m									
29 Su	☿ in mer. 10-12 eve. ☿				☿	☿	4 41	7 31	1 34	4 55	7 17	1 44	10 3	
30 M	Vega mer. 10 eve.					☿	4 42	7 30	2 20	4 56	7 16	2 31	10 56	
31 Tu	Milkmaid's Dipper mer. 10 eve.					☿	4 43	7 29	3 16	4 56	7 15	3 26	11 49	



MOON'S PHASES						Sun on Meridian	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.				CALENDAR for N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kana., Neb., Colo., Utah, Nev., and No. Cal.				Moon's Position or Meridian Passage
Eastern Time		Central Time		Sun on Meridian Civil Time		MOON'S PLACE	Sun rises	Sun sets	Moon rises	Sun rises	Sun sets	Moon rises	morn.		
D.	H. M.	D.	H. M.	D.	H. M. S.		C.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	
☾	1 10 30M	1 9 30M	1 12 6 10			☿	4 44	7 27	rises	4 57	7 14	rises	morn.		
☽	8 0 24E	8 11 24M	11 12 5 3			♈	4 46	7 26	8 33	4 58	7 13	8 27	41		
☿	15 8 49M	15 7 49M	21 12 3 1			♉	4 47	7 25	9 1	4 59	7 12	8 57	1 32		
♈	23 3 21M	23 2 21M	28 12 1 7			♊	4 48	7 24	9 26	5 0	7 11	9 24	2 21		
☌	30 9 34E	30 8 34E													
Day Astronomy, Church Days, etc.						C.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.		
1W	☿ rises 1:30-3:30 mo. W ☐ ☉ ☌					☿	4 44	7 27	rises	4 57	7 14	rises	morn.		
2Th	Pres. Harding died '23					♈	4 46	7 26	8 33	4 58	7 13	8 27	41		
3Fr	♊ sets 12 eve.-2 mo.					♉	4 47	7 25	9 1	4 59	7 12	8 57	1 32		
4Sa	Nor. Crown sets 1-2 mo.					♊	4 48	7 24	9 26	5 0	7 11	9 24	2 21		
32. 9th Sunday after Trinity Length of Day 14h 9m—of Twilight 1h 49m															
5Su	Antares mer. 7:40 eve. ♂ δ) X					♈	4 49	7 22	9 50	5 1	7 10	9 50	3 8		
6M	Transfiguration X					♈	4 50	7 21	10 14	5 2	7 9	10 16	3 56		
7Tu	Name of Jesus M T					♈	4 51	7 19	10 39	5 3	7 8	10 43	4 44		
8W	Markab mer 2 mo. ♀ 1° N. of ♀ M					♈	4 52	7 18	11 8	5 4	7 6	11 13	5 34		
9Th	Harp mer. 9:30 eve. ♂ 35' S. of ♀ M					♈	4 54	7 16	11 42	5 5	7 5	11 50	6 27		
10Fr	Moon Per. ♀ 1° N. of ψ Ω M					♈	4 55	7 15	morn.	5 6	7 4	morn.	7 24		
11Sa	Dog Days end M X					♈	4 56	7 14	25	5 7	7 3	35	8 24		
33. 10th Sunday after Trinity Length of Day 13h 54m—of Twilight 1h 44m															
12Su	Altair mer. 10:24 eve. ♀ X					♈	4 57	7 12	1 17	5 8	7 2	1 27	*9 25		
13M	Spica sets 9:15 eve. ♀ X					♈	4 58	7 10	2 18	5 9	7 0	2 28	10 26		
14Tu	Corvus sets 7-8 eve. ♀ X					♈	5 0	7 9	3 28	5 10	6 59	3 37	11 25		
15W	Andromeda rises 8 eve. ♀ X					♈	5 1	7 7	sets	5 11	6 58	sets	ev. 19		
16Th	☿ rises 9-11 ev. ♂ ♀) ♂ ♀ ☉ Supr.					♈	5 2	7 6	8 10	5 12	6 56	8 2	1 9		
17Fr	Job's Coffin mer. 11 eve. ♀ X					♈	5 3	7 4	8 33	5 13	6 55	8 31	1 55		
18Sa	Menkar rises 11 eve. ♂ ♀ ψ X					♈	5 4	7 3	8 55	5 14	6 53	8 54	2 38		
34. 11th Sunday after Trinity Length of Day 13h 38m—of Twilight 1h 37m															
19Su	Deneb mer. 10:50 eve. ♀ X					♈	5 6	7 1	9 16	5 14	6 52	9 17	3 21		
20M	Cetus sets 2-5 mo. ♀ X					♈	5 7	6 59	9 36	5 15	6 51	9 40	4 2		
21Tu	Arcturus sets 11 eve. ♀ X					♈	5 8	6 58	9 59	5 16	6 49	10 3	4 45		
22W	= sets 9-11 eve. ♂ ♀ ☉ X					♈	5 9	6 56	10 24	5 17	6 48	10 30	5 28		
23Th	Moon Apogee M					♈	5 10	6 55	10 53	5 18	6 46	11 1	6 14		
24Fr	St. Bartholomew ♂ b) X					♈	5 11	6 52	11 28	5 19	6 45	11 38	7 2		
25Sa	X sets 7-9 eve. ♀ X					♈	5 13	6 51	morn.	5 20	6 43	morn.	7 53		
35. 12th Sunday after Trinity Length of Day 13h 21m—of Twilight 1h 36m															
26Su	Lyra mer. 8 eve. ♀ X					♈	5 14	6 49	11	5 21	6 42	22	8 45		
27M	= mer. 11:30 eve.-1:30 mo. ♀ X					♈	5 15	6 47	1 3	5 22	6 40	1 13	9 39		
28Tu	♈ mer. 10-12 eve. ♀ X					♈	5 16	6 46	2 3	5 23	6 39	2 13	10 32		
29W	John the Baptist beheaded ♀ X					♈	5 17	6 44	3 10	5 24	6 37	3 18	11 23		
30Th	Auriga mer. 6:30-7:30 mo. =					♈	5 18	6 42	rises	5 25	6 36	rises	morn.		
31Fr	Rigel rises 1 mo. =					♈	5 20	6 40	7 29	5 26	6 34	7 26	14		

Ninth
Month

September

Thirty
Days

MOON'S PHASES						Sun on Meridian		MOON'S PLACE	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			CALENDAR for N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's Position or Meridian Passage
Eastern Time		Central Time		Civil Time		C.	H.M.		H.M.	H.M.	H.M.	H.M.	H.M.		
D.	H. M.	D.	H. M.	D.	H. M. S.										
6	5 35E	6	4 35E	1	11 59 54										
13	8 21E	13	7 21E	11	11 56 33										
21	9 58E	21	8 58E	21	11 53 1										
29	7 42M	29	6 42M	28	11 50 37										
Day	Astronomy, Church Days, etc.					C.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.		
1	Sa	Jap. earthquake '23					M	X	5 21	6 38	7 53	5 27	6 33	7 52	1 3
36. 13th Sunday after Trinity						Length of Day 13h 3m—of Twilight 1h 34m									
2	Su	☉ rises 3-4 mo.				♄	♂	X	5 22	6 36	8 18	5 28	6 31	8 19	1 51
3	M	Labor Day				♄	♂	X	5 23	6 35	8 42	5 29	6 29	8 45	2 40
4	Tu	Moon Perigee 2 42' N. of ♀				♄	♂	X	5 24	6 33	9 9	5 30	6 28	9 15	3 30
5	W	♄ rises 0-2 mo.				♄	♂	X	5 26	6 31	9 42	5 31	6 26	9 50	4 23
6	Th	Aldebaran rises 10 eve.				♄	♂	X	5 27	6 29	10 22	5 32	6 24	10 30	5 19
7	Fr	♄ mer. 3-5 mo. ♂ 2° S. of ♀				♄	♂	X	5 28	6 27	11 10	5 33	6 23	11 20	6 18
8	Sa	Nativity of Mary				♄	♂	X	5 29	6 25	morn.	5 34	6 21	morn.	7 18
37. 14th Sunday after Trinity						Length of Day 12h 46m—of Twilight 1h 34m									
9	Su	7 Stars rise 9 eve.				♄	♂	X	5 30	6 22	9	5 34	6 20	19	8 18
10	M	Castor rises 0:4 mo. ♂ ♀ ♀ M				♄	♂	X	5 32	6 20	1 14	5 35	6 18	1 24	9 16
11	Tu	Job's Coffin mer. 9 eve.				♄	♂	X	5 33	6 18	2 25	5 36	6 16	2 33	10 11
12	W	Defenders' Day (Md.) Gov. Test Day				♄	♂	X	5 34	6 16	3 36	5 37	6 15	3 42	11 1
13	Th	♄ sets 8-10 eve.				♄	♂	X	5 35	6 14	4 47	5 38	6 13	4 51	11 48
14	Fr	Holy Cross. ♀ ♀ Western				♄	♂	X	5 36	6 12	sets	5 39	6 12	sets	ev. 32
15	Sa	Hyades rise 10 eve. ♂ ♀				♄	♂	X	5 38	6 10	7 19	5 40	6 10	7 19	1 15
38. 15th Sunday after Trinity						Length of Day 12h 27m—of Twilight 1h 34m									
16	Su	Deneb mer. 9 eve.				♄	♂	X	5 39	6 8	7 38	5 41	6 8	7 40	1 57
17	M	Procyon rises 2 mo.				♄	♂	X	5 40	6 6	8 0	5 42	6 7	8 4	2 39
18	Tu	Altair mer. 8 eve.				♄	♂	X	5 41	6 5	8 24	5 43	6 5	8 30	3 22
19	W	Ember Day. Moon Apogee				♄	♂	X	5 42	6 3	8 52	5 44	6 3	9 0	4 7
20	Th	Fomalhaut m. 11:18 ev. ♂ ♀				♄	♂	X	5 44	6 1	9 24	5 45	6 2	9 33	4 54
21	Fr	Ember Day. St. Matthew				♄	♂	X	5 45	6 0	10 3	5 46	6 0	10 13	5 44
22	Sa	Ember Day				♄	♂	X	5 46	5 59	10 51	5 47	5 59	11 1	6 35
39. 16th Sunday after Trinity						Length of Day 12h 9m—of Twilight 1h 33m									
23	Su	☉ ent. =, Autumn begins				♄	♂	X	5 47	5 57	11 46	5 48	5 57	11 56	7 27
24	M	American Indian Day				♄	♂	X	5 48	5 55	morn.	5 49	5 55	morn.	8 20
25	Tu	♄ rises 7-9 eve.				♄	♂	X	5 50	5 53	50	5 50	5 53	59	9 11
26	W	Betelgeuse mer. 10:40 eve. M				♄	♂	X	5 51	5 51	1 59	5 51	5 52	2 7	10 2
27	Th	Arcturus sets 8:36 eve.				♄	♂	X	5 52	5 48	3 11	5 52	5 50	3 17	10 52
28	Fr	Harp mer. 6-7 eve. ♂ ♀				♄	♂	X	5 53	5 47	4 25	5 53	5 48	4 29	11 43
29	Sa	Swan mer. 7-8 eve. ♂ ♀				♄	♂	X	5 55	5 46	rises	5 54	5 47	rises	morn.
40. 17th Sunday after Trinity						Length of Day 11h 50m—of Twilight 1h 32m									
30	Su	Michaelmas ♀ Gr. El. E.				♄	♂	X	5 56	5 44	6 44	5 55	5 45	6 46	3

Tenth
Month



October



Thirty-one
Days

MOON'S PHASES									Sun on			MOON'S PLACE	CALENDAR for			CALENDAR for			Moon's Position or Meridian Passage			
Eastern Time			Central Time			Meridian Civil Time			New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.				N. J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's						
	D.	H.	M.	D.	H.	M.	D.	H.	M.	S.		Sun rises	Sun sets	Moon rises	Sun rises	Sun sets	Moon rises	Moon sets				
	Day											H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.				
☾	6	0	6M	5	11	6M	1	11	49	38	♏	5 57	5 42	7 11	5 56	5 44	7 15	1 22				
☾	13	10	56M	13	9	56E	11	11	46	44	♏	5 58	5 40	7 42	5 56	5 42	7 48	2 16				
☾	21	4	6E	21	3	6E	21	11	44	40	♏	6 0	5 38	8 20	5 57	5 40	8 28	3 12				
☾	28	5	43E	28	4	43E	28	11	43	50	♏	6 1	5 36	9 5	5 58	5 39	9 15	4 11				
☾											♏	6 2	5 34	10 2	6 0	5 37	10 12	5 12				
☾											♏	6 3	5 32	11 6	6 1	5 35	11 16	6 13				
41. 18th Sunday after Trinity																			Length of Day 11h 32m—of Twilight 1h 31m			
☾	7	Su	Capella mer. 4 mo.	♏	6	5	5	31	morn.		♏	6	2	5	34	morn.		7	12			
☾	8	M	Rigel mer. 4 mo.	♏	6	6	5	29	15		♏	6	3	5	32	23		8	7			
☾	9	Tu	Mirach mer. 12 eve.	♏	6	7	5	27	1 26	♏	6	4	5	31	1 33	8	57	8	57			
☾	10	W	♏ rises 9-11 eve.	♏	6	8	5	25	2 35	♏	6	5	5	29	2 40	9	45	9	45			
☾	11	Th	♏ sets 6-7 eve.	♏	6	10	5	23	3 42	♏	6	6	5	28	3 46	10	29	10	29			
☾	12	Fr	Columbus Day	♏	6	11	5	22	4 49	♏	6	7	5	26	4 50	11	12	11	12			
☾	13	Sa	Hyades rise 8 eve.	♏	6	12	5	20	5 52	♏	6	8	5	24	5 52	11	53	11	53			
42. 19th Sunday after Trinity																			Length of Day 11h 14m—of Twilight 1h 31m			
☾	14	Su	♏ mer. 0:30-2:30 mo.	♏	6	14	5	18	sets	♏	6	9	5	23	sets		ev. 35	6	9			
☾	15	M	♏ sets 9-11 eve.	♏	6	15	5	16	6 26	♏	6	10	5	22	6 32	1	18	6	10			
☾	16	Tu	Alpheratz mer. 10:24 eve.	♏	6	16	5	15	6 51	♏	6	11	5	20	6 58	2	2	6	11			
☾	17	W	Moon Apogee	♏	6	18	5	13	7 23	♏	6	12	5	18	7 31	2	48	6	12			
☾	18	Th	St. Luke	♏	6	19	5	11	7 58	♏	6	13	5	17	8 8	3	37	6	13			
☾	19	Fr	♏ mer. 6-8 eve.	♏	6	20	5	9	8 42	♏	6	14	5	16	8 52	4	27	6	14			
☾	20	Sa	Aldebaran mer. 2 mo.	♏	6	21	5	8	9 34	♏	6	15	5	14	9 45	5	18	6	15			
43. 20th Sunday after Trinity																			Length of Day 10h 57m—of Twilight 1h 33m			
☾	21	Su	Algenib mer. 10:11 eve.	♏	6	23	5	6	10 33	♏	6	16	5	13	10 43	6	10	6	16			
☾	22	M	Hyades mer. 2-3 mo.	♏	6	24	5	4	11 39	♏	6	17	5	11	11 47	7	0	6	17			
☾	23	Tu	☐ of Pegasus mer. 10 eve.	♏	6	26	5	3	morn.	♏	6	18	5	10	morn.	7	50	6	18			
☾	24	W	Cross sets 2-3 mo.	♏	6	27	5	1	47	♏	6	19	5	9	53	8	39	6	19			
☾	25	Th	Mira (Var.) mer. 12 eve.	♏	6	28	5	0	1 59	♏	6	21	5	7	2 3	9	28	6	21			
☾	26	Fr	Dolphin mer. 6 eve.	♏	6	29	4	59	3 12	♏	6	22	5	6	3 14	10	17	6	22			
☾	27	Sa	Roosevelt's birthday. Navy Day	♏	6	31	4	57	4 28	♏	6	23	5	5	4 28	11	8	6	23			
44. 21st Sunday after Trinity																			Length of Day 10h 39m—of Twilight 1h 34m			
☾	28	Su	Simon and Jude, Kingdom of Christ	♏	6	32	4	55	rises	♏	6	24	5	3	rises		morn.	6	24			
☾	29	M	♏ 2 0 & 2 50' N. of ☐	♏	6	34	4	54	5 39	♏	6	25	5	2	5 45	1		6	25			
☾	30	Tu	Moon Perigee	♏	6	35	4	52	6 14	♏	6	26	5	1	6 22	58		6	26			
☾	31	W	Hallowe'en	♏	6	36	4	51	6 58	♏	6	27	5	0	7 8	1	58	6	27			

Eleventh
Month



November



Thirty
Days

MOON'S PHASES			Sun on Meridian		MOON'S PLACE	CALENDAR for New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			CALENDAR for N.J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.			Moon's Southing or Meridian Passage
Eastern Time	Central Time	D. H. M.	D. H. M.	Civil Time		Sun rises	Sun sets	Moon rises	Sun rises	Sun sets	Moon rises	
☾ 4 9 6M	4 8 6M	11 11 43	38		☾	6 38	4 49	7 52	6 28	4 58	8 2	3 1
● 12 4 35M	12 3 35M	11 11 44	7		☾	6 39	4 48	8 55	6 30	4 57	9 6	4 4
☽ 20 8 36M	20 7 36M	21 11 45	59		☽	6 40	4 46	10 5	6 31	4 56	10 15	5 6
☾ 27 4 5M	27 3 5M	28 11 48	5		☾							
Day	Astronomy, Church Days, etc.					H.M.	H.M.	H.M.	H.M.	H.M.	H.M.	H.M.
1Th	All Saints				☾	6 38	4 49	7 52	6 28	4 58	8 2	3 1
2Fr	All Souls			♂ ♂ M	☾	6 39	4 48	8 55	6 30	4 57	9 6	4 4
3Sa	♂ rises 10-12 eve.				☾	6 40	4 46	10 5	6 31	4 56	10 15	5 6

45. 22nd Sunday after Trinity

Length of Day 10h 23m—of Twilight 1h 34m

4Su	☾ rises 8-10 eve.	☾	6 42	4 45	11 17	6 32	4 55	11 25	6 3
5M	♂ rises 1-3 mo.	♂ ♀ M	6 43	4 44	morn.	6 33	4 54	morn.	6 55
6Tu	General Elections	☾	6 44	4 42	26	6 34	4 53	32	7 43
7W	Fomalhaut m. 8 ev. ♀ 2°41'S. of b	☾	6 46	4 41	1 35	6 35	4 52	1 39	8 28
8Th	7 Stars rise 5 eve.	☾	6 47	4 40	2 40	6 36	4 51	2 42	9 11
9Fr	Capella m. 1:57 mo. ♀ Gr. El. WM.	☾	6 49	4 39	3 44	6 38	4 50	3 44	9 52
10Sa	Sirius mer. 3:10 mo. ♀ in Aph.	☾	6 50	4 37	4 48	6 39	4 49	4 46	10 33

46. 23rd Sunday after Trinity

Length of Day 10h 8m—of Twilight 1h 35m

11Su	Armistice D. Tex., Fla. Martinmas M	☾	6 51	4 36	5 51	6 40	4 48	5 47	11 15
12M	☉ Par. Eclipse ♂ Sta.	M	6 51	4 35	6 55	6 41	4 47	6 49	11 59
13Tu	♂ mer. 11 eve.-1 mo.	☾	6 54	4 34	sets	6 42	4 46	sets	ev. 44
14W	Moon Apogee ♂ b M	☾	6 56	4 33	5 57	6 43	4 45	6 7	1 32
15Th	Dolphin m. 5 eve. ♀ 43' S. of	☾	6 57	4 32	6 37	6 44	4 44	6 48	2 22
16Fr	Arbor Day, S. C.	☾	6 58	4 31	7 26	6 46	4 44	7 37	3 12
17Sa	Algenib mer. 8:14 eve.	☾	7 0	4 30	8 22	6 47	4 43	8 32	4 3

47. 24th Sunday after Trinity

Length of Day 9h 54m—of Twilight 1h 36m

18Su	☾ mer. 8-10 eve.	☾	7 1	4 29	9 24	6 48	4 42	9 33	4 54
19M	Ell & Yard mer. 1:34 mo.	☾	7 2	4 28	10 30	6 49	4 41	10 38	5 43
20Tu	Whale mer. 8-11 eve.	☾	7 4	4 27	11 39	6 50	4 41	11 45	6 30
21W	Aquila sets 10 eve.	☾	7 5	4 26	morn.	6 51	4 40	morn.	7 17
22Th	☾ sets 4 mo.	☾	7 6	4 25	49	6 52	4 39	53	8 4
23Fr	☾ mer. 2-4 mo.	♂ ♂ M	7 8	4 25	2 1	6 54	4 39	2 3	8 53
24Sa	Gt. + sets 1-2 mo.	☾	7 9	4 24	3 15	6 55	4 38	3 14	9 43

48. 25th Sunday after Trinity

Length of Day 9h 42m—of Twilight 1h 37m

25Su	☾ mer. 6-8 eve. 2 1° N. of	☾	7 10	4 23	4 34	6 56	4 38	4 30	10 38
26M	Hyades mer. 12 eve.	M	7 11	4 23	5 57	6 57	4 37	5 51	11 37
27Tu	Moon Perigee.) Tot. Ecl. ♂ M	☾	7 13	4 22	rises	6 58	4 37	rises	morn.
28W	☾ sets 10:30 eve.	M	7 14	4 22	5 35	6 59	4 37	5 45	40
29Th	Thanksgiving Day. Close ♂ ♂	☾	7 15	4 21	6 36	7 0	4 36	6 47	1 46
30Fr	St. Andrew	☾	7 16	4 21	7 47	7 1	4 36	7 57	2 51

Twelfth
MonthThirty-one
Days

MOON'S PHASES					Sun on Meridian		MOON'S PLACE	CALENDAR for			CALENDAR for			Moon's Southing or Meridian Passage	
Eastern Time		Central Time		Civil Time		New Eng., N. York, Mich., Wis., Minn., N. and S. Dak., Mont., Wyo., Ida., Wash. and Oregon.			N. J., Pa., Md., Del., Va., W. Va., Ky., Ind., O., Ill., Mo., Ia., Kans., Neb., Colo., Utah, Nev., and No. Cal.						
D. H. M.	D. H. M.	D. H. M.	D. H. M.	D. H. M.	D. H. M. S.	Sun rises		Sun sets	Moon rises	Sun rises	Sun sets	Moon rises			
Day	Astronomy, Church Days, etc.							H. M.	H. M.	H. M.	H. M.	H. M.	H. M.		
1	Sa	[Gt. Neb. of Andromeda m. 7:30 ev.]						7 17	4 20	9 1	7 2	4 36	9 10	3 52	
49. Advent Sunday							Length of Day 9h 33m—of Twilight 1h 36m								
2	Su	Algenib mer. 7:25 eve.						♄	7 19	4 20	10 15	7 3	4 36	10 21	4 49
3	M	♄ rises 4-6 mo.						♄ ♄	7 20	4 20	11 25	7 4	4 36	11 29	5 40
4	Tu	Rigel mer. 0:19 mo.						♄	7 21	4 19	morn.	7 5	4 35	morn.	6 27
5	W	Mira (Var.) mer. 6:18 eve.						♄	7 22	4 19	32	7 6	4 35	34	7 10
6	Th	♄ mer. 9-11 eve.						♄	7 23	4 19	1 37	7 7	4 35	1 37	7 52
7	Fr	Arbor Day, Ga.						♄	7 24	4 19	2 40	7 8	4 35	2 38	8 33
8	Sa	Conception B. V. M.						♄	7 25	4 18	3 43	7 9	4 35	3 39	9 14
50. 2nd Sunday in Advent							Length of Day 9h 25m—of Twilight 1h 36m								
9	Su	Sirius mer. 1:14 mo.						♄	7 26	4 18	4 46	7 10	4 35	4 41	9 57
10	M	Capella mer. 12 eve.						♄	7 27	4 18	5 50	7 10	4 35	5 43	10 42
11	Tu	Moon Apogee						♄ ♄	7 28	4 18	6 53	7 11	4 35	6 44	11 29
12	W	Altair sets 9 eve.						♄	7 29	4 18	sets	7 12	4 35	sets	ev. 18
13	Th	♄ mer. 6-8 eve.						♄ ♄	7 30	4 19	5 22	7 13	4 35	5 33	1 8
14	Fr	♄ mer. 1 mo.						♄	7 30	4 19	6 17	7 14	4 36	6 27	1 59
15	Sa	♄ nearest earth.						♄ ♄ ♄ ♄	7 31	4 19	7 18	7 14	4 36	7 27	2 50
51. 3rd Sunday in Advent							Length of Day 9h 21m—of Twilight 1h 37m								
16	Su	Castor mer. 2 mo.						♄	7 32	4 19	8 22	7 15	4 36	8 30	3 39
17	M	Hyades mer. 10:30 eve.						♄	7 33	4 20	9 28	7 16	4 37	9 34	4 26
18	Tu	Hercules m. 6-8 eve.						♄ ♄ ♄	7 33	4 20	10 36	7 16	4 37	10 40	5 12
19	W	Ember Day						♄	7 34	4 20	11 45	7 17	4 37	11 47	5 58
20	Th	Pleiades mer. 10 eve.						♄	7 34	4 20	morn.	7 18	4 38	morn.	6 43
21	Fr	Ember Day. St. Thomas						♄ ♄ ♄	7 35	4 21	55	7 18	4 38	55	7 31
22	Sa	Ember Day. Winter begins						♄ ♄	7 36	4 22	2 8	7 19	4 39	2 6	8 21
52. 4th Sunday in Advent							Length of Day 9h 21m—of Twilight 1h 37m								
23	Su	♄ sets 8-10 eve.						♄	7 36	4 22	3 25	7 19	4 40	3 20	9 16
24	M	Job's Coffin sets 9 eve.						♄	7 36	4 23	4 47	7 20	4 40	4 40	10 16
25	Tu	Christmas Day						♄	7 37	4 23	6 10	7 20	4 41	6 1	11 20
26	W	St. Stephen. Moon Perigee.						♄ ♄	7 37	4 24	rises	7 20	4 41	rises	morn.
27	Th	St. John.) highest of year						♄	7 37	4 24	5 20	7 21	4 42	5 30	27
28	Fr	Holy Innocents						♄	7 38	4 25	6 36	7 21	4 42	6 45	1 32
29	Sa	Betelgeuse mer. 11:20 eve.						♄	7 38	4 26	7 53	7 21	4 43	8 0	2 34
53. 1st Sunday after Christmas							Length of Day 9h 21m—of Twilight 1h 37m								
30	Su	Aldebaran mer. 9:40 eve.						♄ ♄	7 38	4 27	9 9	7 22	4 43	9 14	3 29
31	M	Capella mer. 10:33 eve.						♄	7 38	4 28	10 20	7 22	4 44	10 23	4 19

LENT

Lent, which begins on Ash Wednesday, is the period of fasting before the joyous reawakening of Easter. Between Ash Wednesday and Easter Sunday is a period of forty days, not counting Sundays. Rigorous abstinence from all forms of worldly indulgence marks the time, in some Christian denominations.

The word "Lent" is derived from the Saxon or old English word "Lencten," signifying spring, and that name, in turn, has a common origin with the word "length." That is, Lent corresponds roughly with the first part of the season when the days begin to lengthen, after the vernal equinox.

The fast of Lent was called by the Latins "Quadragesima" or "forty," but whether that name was given to it on account of its being originally a fast of forty days, or only forty hours, is a point that has been much disputed by writers on religious topics. Some church historians incline to the opinion that it was, at first, only forty hours. St. Jerome, St. Leo, St. Augustine and some others believe that the fast was instituted by the Apostles, but by others it is asserted that it was not known in the earliest ages of the church.

In the time of Irenæus, a rigid fast was observed for forty hours before Easter morning. In Alexandria, during the third century after Christ, the adherents to the new religion fasted throughout "Holy Week," and by the fourth century the period had been extended to about forty days. Hence, in Rome, it was called "Quadragesima," from the Sunday which was the fortieth day before Easter. In the eighth or ninth century it was decided that the fast should begin on Ash Wednesday.

LENT IN THE MIDDLE AGES

In England, in the Middle Ages and later, the observance of Lent seems to have been sometimes more a matter of secular importance than of religious observance. This was especially attributed to the desire of the rulers of the land to increase the consumption of fish and to conserve the supply of meat. Therefore, after the Reformation, the regu-

lations enjoined abstinence from flesh in as strict a manner, though not, ostensibly, on the same grounds, as by the Roman Catholic Church.

In 1548, when Edward VI., the Protestant "boy king," occupied the throne, a statute reads: "In the time commonly called Lent, the King's Majesty considering that due and godly abstinence is a means to virtue, and to subdue men's bodies to their soul and spirit, and considering also especially that fishers and men using the trade of fishing in the sea may thereby be set to work, and that by eating of fish much flesh will be saved and increased," &c., and declares, after repealing all existing laws on the subject, that such as eat flesh in the forbidden season of Lent shall incur a penalty of ten shillings, or ten days' imprisonment without flesh; a double penalty was provided for a second offense.

In the next reign but one, that of Elizabeth, a statute was passed for abstinence from meat in Lent, but this time it was asserted expressly that the law was passed not for religious ends, but entirely to encourage the increase of fishery. No one, unless he had a special license, was permitted to eat meat on fish days, or on Wednesdays, now made an additional fish day, under a penalty of three pounds fine or three months' imprisonment. But anyone who had three dishes of seafood on his table might have one of flesh also. It was said in the statute that the "eating of fish or forbearing of flesh is of no necessity for the saving of the soul of man, or for the service of God, otherwise than as other politic laws are and be."

OBSERVANCE MADE COMPULSORY

The compulsory observance of Lent as a season of abstinence from the eating of flesh and other carnal indulgences was prescribed by the law of England long after the Reformation, but, from the very beginning, it was really only compulsory on the poor. Licenses for eating flesh and white meats during Lent were easily obtain-

able by payment, legitimate or otherwise, to the officers of the law. The Englishmen of those times did not take kindly to such enactments. To supplement the laws, many royal proclamations were issued.

Howell, in one of his "Letters," dated Ash Wednesday in the year 1654, comments as follows upon the religious and secular observance of Lent:

"Now that Lent and the Spring do make their approach, in my opinion fasting would conduce much to the advantage of the soul and body; though our second institution of observing Lent aimed at civil respects, as to preserve the brood of cattle, and advance the profession of fishermen, yet it concurs with the first institution, namely, a pure spiritual end, which was to subdue the flesh, and that being brought under, our

other two spiritual enemies, the world and the devil, are the sooner overcome. The naturalists observe, that morning spittle kills dragons; so fasting helps to destroy the devil, provided it be accompanied with other acts of devotion; to fast for one day only, from about nine in the morning until four in the afternoon, is but a mock fast."

He expressed the same sentiment in verse (not very good verse, however), as follows:

This is not to keep Lent aright,
But play the juggling hypocrite;
He truly Lent observes, who makes the
inward man
To fast, as well as make the outward
feed on bran.

—Eugene Van Cleef in
Tycos—Rochester.

KOREAN LESPEDEZA

MAKES GOOD PASTURE ON POOR SOIL

A small package of seed sent to the United States Department of Agriculture from Korea seven years ago has upheld the old saying, "good things come in small packages." Sown at the department's experimental farm at Arlington, Va., in a row a rod long which yielded eight ounces of seed, the material proved to be a species of lespedeza new to the United States. Careful handling in order to increase this small seed supply and subsequent testing at various state experiment stations has shown the new introduction to be a valuable addition to the forage crops of this country.

The Korean lespedeza, although closely related to the Japanese species commonly found in the south, is earlier and adaptable to regions farther north. It is quite drought resistant and grows readily on poor acid soils. It is a legume and is recommended chiefly as a summer pasture crop rather than as a hay crop. Its value lies in the fact that it will reseed the ground and will grow in the hot months when grass on poor droughty land is brown and dead.

Although grown only on a limited acreage as yet, on account of an insuffi-

cient seed supply, Korean lespedeza promises to be especially important for a section of the country described as lying between southern Pennsylvania and northern Ohio on the north and the southern border of Virginia and Kentucky on the south, extending from the Atlantic coast to Iowa. It has also given promise in Kansas, on the eastern border of the Great Plains, but how far west it may prove valuable is not yet known.

The great need at present to further the establishment of this new legume is a sufficient seed supply. There is a demand for all the seed that can be grown for several years yet to come, says the department, and the few farmers who already have a small acreage are urged to harvest a supply of seed for sale. Although lespedeza will grow readily at points farther north than the zone described, it does not mature seed there. In the adapted region mentioned the plant produces a plentiful supply of seed. Seed is harvested by cutting the crop with a mower, raking, and threshing in much the same manner as timothy is threshed.—U. S. Dept. of Agriculture.

THE HYDROGEN ATOM

CHEMISTRY OF ATOMIC COMBINATIONS

The chemist is busy with a new toy. This time his plaything is the atom of hydrogen. As the small boy is initiated into the lore of chemistry with experiments on molecular hydrogen, producing with delight, sometimes with disaster, sonorous explosions, so the trained chemists in Berkeley and Berlin, in Pasadena and Princeton are today turning their investigations to the properties of the atom of the same species, with results rich in suggestiveness and application.

Atomic hydrogen is not a new product; it is however, newly recognized. The substance is made familiar to the student of general chemistry in that non-committal phrase, "nascent hydrogen." For, it was early recognized that hydrogen at birth possessed properties which it ceased to possess after birth. By isolating atoms of hydrogen and studying their properties, the chemist has shown that these properties are those of nascent hydrogen.

When first born, hydrogen is generally in the atomic condition. The atoms twin with one another to form molecules of hydrogen, and this is the molecular product with which everyone is familiar, which is used for the filling of toy balloons and dirigibles, and in a number of important industrial enterprises. It has a bad reputation both in aeronautics and industry because of its inflammability; the dirigible airship in flames, and explosions of gas can both be traced to the reactivity of ordinary hydrogen, its combustibility in air. Compared with atomic hydrogen, however, molecular hydrogen is tame and unreactive.

"... LIKE A PLANET AROUND A SUN"

The dictionary states that the word "protyle" (from the Greek, *πρωτος*, *protos*, meaning first or primary and *υλη*, *ule*, meaning stuff or material) is a "hypothetical primordial substance supposedly differentiated into what are recognized as distinct chemical elements." To the chemist the hydrogen atom is

the protyle; it is his primordial substance, but it is, however, no longer hypothetical.

To the physicist, on the contrary, the protyle is subdivisible. The modern theory of atomic structure assigns to the hydrogen atom a single proton or unit charge of positive electricity and a single negative electron which describes an orbital path around the proton like a planet around a sun. The physicist represents the atom by a diagram in which several possible electron orbits around the proton are shown. With such a concept, the spectroscopic and electrical properties of atomic hydrogen can be successfully represented and forecast.

To produce and isolate atomic hydrogen it is necessary to disrupt the molecules, to tear apart the constituent units. It is also necessary to study the properties of these units before they can recombine with one another. This was first accomplished by Langmuir of the General Electric Company at Schenectady, who showed that hydrogen at very low pressures dissociated into atoms when it came in contact with a tungsten filament at the high temperature of the incandescent lamp. The energy of the heated filament was consumed in tearing apart the molecule. The low pressure reduced the number of collisions between the atoms so formed and enabled Langmuir to show that they possessed remarkable properties. They clung tenaciously to the glass walls of the containing vessel wherever they struck, thereby reducing the gas pressure in the vessel. Their reactivity as compared with ordinary molecular hydrogen was revealed in the ease with which they reduced oxides to metals. Thus, black oxide of copper was transformed at ordinary temperatures to the bright lustrous red metal, a reduction for which a temperature of hundreds of degrees is required with molecular hydrogen.

Langmuir was able to calculate that it required the input of 100,000 calories of energy to bring about the dissociation

of two grams of hydrogen molecules into the constituent atoms. Did the dissociation into atoms not occur, this energy would suffice to raise the temperature of the gas to 20,000 degrees, Centigrade (36,000 degrees, Fahrenheit), a temperature about four times greater than that of the sun. This same energy is in part available when hydrogen atoms recombine. How this became feasible, even on a practical scale, is a further chapter in the story of atomic hydrogen.

Professor R. W. Wood, physicist of Johns Hopkins University, showed that, in an electric current of sufficient potential and concentration, there resides the energy necessary to tear apart the two hydrogen atoms of ordinary molecular hydrogen gas. In his experiments, electric discharges were passed through hydrogen at low pressures, and the atoms were removed from the discharge tube by vacuum pumps.

Langmuir and his associates have shown, however, that the discharge may be sent through jets of hydrogen gas at ordinary atmospheric pressure. Hydrogen atoms may thus be obtained in concentrations such that, by the energy of recombination of the atoms, the attainment of temperatures far beyond those available with the oxy-acetylene flame, rivalling even those of the electric torch, is readily accomplished. A new welding tool has been produced. Flames of atomic hydrogen are now at the disposal of the metal worker. The most refractory metals yield to the new welding process and the industrial applications are already numerous. The process has especial advantages in that the flame is free from carbon, which is an objectionable constituent in many metal-welding operations.

Yet another method of reaching the hydrogen molecule with the energy necessary for its disruption has been devised by the physicist, a method of particular interest to the chemist in that, by its aid, cold hydrogen atoms may be produced under conditions which favor a study of their chemical properties. The device which is used to supply the large amount of energy necessary to disrupt the molecule without increasing the temperature, is to make use of light energy.

The modern developments in the theory of light, based upon the so-called "quantum theory," teach that light consists of bundles or "quanta" of energy, each bundle of a certain color corresponding to a known and definite amount of energy. Thus, the light given out by a flame, colored yellow with ordinary common salt, the D sodium line, corresponds to an energy of 48,000 calories. The 100,000 calories of energy necessary to break up hydrogen mole-



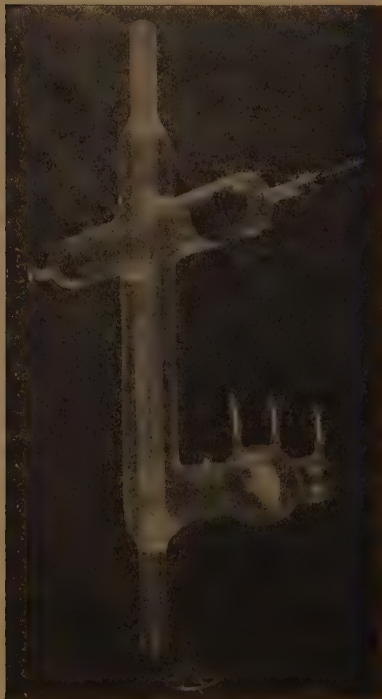
DR. HUGH S. TAYLOR

cules into atoms corresponds to light in the ultra-violet, beyond the visible range of a wavelength which the physicist states as approximately 2,600 units.

QUARTZ GLASS NECESSARY

Hydrogen, however, does not absorb such light. It therefore became necessary to find a substance which would absorb such light and transmit it to hydrogen. Two German physicists, Franck and Cario, found such an agent in mercury vapor. This gas, when present even in the minute amount of one part in 10,000 of a gas mixture, will absorb completely the light emitted by a cooled mercury arc having a wave-

length of 2,537 Angstrom units. Bundles of this energy correspond to a heat energy of 112,000 calories, or more than sufficient to disrupt molecular hydrogen. Atoms of mercury which have absorbed this energy are known as "excited" mercury atoms. Should an "excited" atom of mercury collide with a hydrogen molecule, an energy transfer would occur, the energy being used up in the



HOW THE LIGHT IS PRODUCED

formation of two hydrogen atoms, and the mercury atom relaxing into its normal state.

The whole process is analogous to the mechanism whereby a lead shot in a sporting cartridge is endowed with sufficient velocity to shiver to pieces a clay pigeon. The atom of mercury is the shot. The light energy which it absorbs

is equivalent to the energy supplied by the percussion cap, the hydrogen molecule is the clay pigeon and the hydrogen atoms are the remnants of the process. By utilizing light energy, all this remarkable exhibition of atomic energy can be achieved in a vessel cooled in ice water.

Since ordinary glass is not transparent to ultra-violet light it has been necessary not only to utilize sources of light energy in apparatus of quartz but also to develop suitable containers of quartz in which the atomic encounters may be achieved. Two very successful examples of such quartz lamps and reaction vessels are shown in the accompanying illustrations. They have been built by quartz glass makers in this country from designs made in Princeton University and probably represent the high-water mark of quartz glass technique yet achieved.

The chemist has taken up the story where the physicist laid it down. By mixing other gases with the hydrogen and mercury it has been possible to ascertain what the subsequent history of the hydrogen atoms is. Experiments in Princeton showed that, if these atoms collided with oxygen, the first product to be formed was not water, but hydrogen peroxide, the substance well known in three percent solution as a disinfectant and also as an industrial bleaching agent. By this method the peroxide could be produced 100 percent pure without any trace of water.

This simple experiment at once made clear the mechanism of two old experiments in which hydrogen peroxide is formed. It has long been known that when an oxy-hydrogen flame was allowed to play on a block of ice a little hydrogen peroxide is formed. The new work indicates that, in the flame, there are present small amounts of atomic hydrogen which react with oxygen to form the peroxide which is stabilized as such on the ice surface. The ice serves to cool the peroxide rapidly from the flame temperature and thus to maintain it undecomposed.

Similarly, when hydrogen is generated by passing an electric current through a solution of sulphuric acid it has also been found that hydrogen peroxide may be produced by allowing oxygen gas to

bubble over the electrode at which the hydrogen is being generated. Hydrogen exists in sulphuric acid solutions as hydrogen ions—the proton of our first diagram. The electric current consists of electrons passing through the conductor to the electrode, at which, therefore, proton and electron unite to form an atom. In the absence of oxygen these atoms accumulate and, by twinning, gradually form molecules and are evolved as such.

But, if the electrode be kept bathed in oxygen gas, the alternative reaction of the atoms with oxygen to form peroxide becomes possible and demonstrable. Two German investigators showed that high pressures of oxygen gas favored the reaction at the electrode surface. Practically quantitative utilization of the electrical energy consumed in the production of the hydrogen was secured and peroxide solutions of medium strength were produced. Their experimental work was carried out, however, before the era of industrial syntheses at elevated pressures, and led to no practical results.

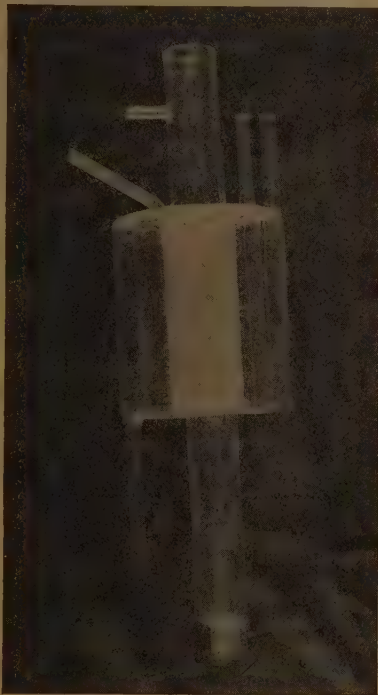
It is possible, however, that a re-examination of this problem may lead to commercial developments of importance, since hydrogen peroxide is one of the most suitable bleaching agents. It owes its value to the fact that it decomposes to water during the bleaching process, so that no harmful ingredients are left in the article bleached.

FORMALDEHYDE BY SYNTHESIS

It has also been shown in Princeton that two hydrogen atoms will add on to carbon monoxide, the resulting product being formaldehyde, the important raw material of bakelite and such synthetic resins. The synthesis of formaldehyde from carbon monoxide and hydrogen atoms, as well as many other reactions of hydrogen atoms now studied, indicate that the extraordinary activity of metals as agents for accelerating chemical reactions is to be ascribed to the presence of hydrogen atoms on the surfaces of such metals when they are brought in contact with molecular hydrogen. It is the attraction of the metal atoms for the separate atoms of the hydrogen molecule which, in this case,

causes the dissociation of the hydrogen into atoms and, hence, the extraordinary activity of such metal-hydrogen systems.

It is on the basis of this attractive force that many important industrial achievements are built, for example, the combination of nitrogen and hydrogen to form ammonia, and the addition of hydrogen to liquid vegetable fats to



ANOTHER QUARTZ ARC-LAMP

make of them hard vegetable fats suitable as lard substitutes.

We have clothed our ignorance of such processes by grouping them together under the high-sounding if somewhat meaningless title of catalysis. Here again, however, can be exemplified the universal experience in science, the illumination of what is dark and little understood in one field by the increase

of knowledge in other, if cognate, fields. The study of the properties of hydrogen atoms has led to the positive identification of hydrogen atoms on metallic surfaces.

The evidence thus obtained points to the presence of hydrogen atoms in metals saturated with hydrogen gas. The speed with which hydrogen passes through massive metals such as palladium and iron even suggests that the process of disruption may be even more complete and that, within the metal, hydrogen may be present not only as atoms but also as protons and electrons.

What a fascinating possibility this thought inspires! For, there at hand,

within the metal, would be the unit bricks from which the atomic architecture may be constructed. The nucleus of helium is, most probably, composed of four protons and two electrons.

Is it of the achievement of this synthesis of an atomic nucleus that recent reports of work by Professor Paneth of Berlin would tell? If so, the broad highway has been indicated to a domain yet richer in potentialities than the chemistry of the present and the past.

The new chemistry would be the chemistry of atomic synthesis. Man's control over matter would be well-nigh complete.—*Hugh S. Taylor, Professor Physical Chemistry, Princeton.*

CHINESE ELM

VALUABLE TREE FOR THE UNITED STATES

Among the many valuable contributions of northern China to American horticulture the Chinese elm stands out as one likely to prove of increasing value to certain sections of the United States, says C. C. Thomas, of the office of Foreign Plant Introduction, United States Department of Agriculture. The tree, introduced in 1908, is now established in a number of places in this country and the seeds and plants are offered for sale by several nurseries in the South and West.

The Chinese elm is very hardy and has proved valuable under a greater variety of climatic and soil conditions than any tree yet introduced. Very favorable reports have been received from practically every section of the country, says Mr. Thomas. The tree has proved winter hardy in most trials in the Dakotas, Minnesota, New York, Montana, and other Northern states. Its resistance to drought, alkali, and extremes of temperature render it an especially valuable tree in the Great Plains region, where desirable shade

trees are few; in the semi-arid South and Southwest, and, in fact, in almost any portion of the continental United States.

The tree is one of the first to leaf out in the spring and the last to shed its leaves in the fall. Throughout the long season the leaves remain a beautiful green and are remarkably free from the usual plant diseases and insect injuries so common in many of the other elms. As a shade, wind-break, and avenue tree it has proved to be the most successful introduction of this kind thus far attempted. Aside from these uses it is likely that it can be used as a hedge also. A recent report from one of the department's explorers in Manchuria states that the tree is used there for hedges two to three feet high, in some instances being used for screens up to 12 or 15 feet in height. Cutting back at the desired height causes it to branch into form suitable for hedges. Efforts are now being made in experimental tests by the department to determine its hedge-making qualities in this country.—*U. S. Department of Agriculture.*

THE CATHODE RAY

WHAT DISCOVERIES WILL FOLLOW?

It is no longer a secret that when the remarkable phenomena produced by means of the newly developed tube described on these pages—especially its effects on small animals at short distances—were first observed, there was considerable fear among scientists that it would receive a bad dose of the wrong kind of initial publicity: it might be described by the sensational press as some new-fangled kind of “death-ray.” No such purpose, it is almost needless to state, was in the minds of the scientists who developed it, and its effect on living matter is so comparatively limited in range that any such idea would be nonsensical.

As anyone may learn from any elementary physics text book, the cathode ray is not in itself a new thing—far from it. What Dr. Coolidge has done, essentially, is to modify the electron-discharge tube formerly used, in such a manner that the rays are powerful *outside*. As the accompanying article states, various interesting phenomena take place under the “super-cathode” rays but direct applications of practical value have not been announced as yet. It is significant, however, in view of this statement, that few have been the developments of this kind which have not soon been applied in some direct manner to industry and our daily lives.

Cathode rays, or streams of high-speed electrons, were discovered by Crookes, an English scientist, in 1875, but their possibilities were limited because it was necessary to work within evacuated tubes. Hertz, in 1892, found that the cathode rays would go through metal foil placed in the vacuum tube. Lenard, his pupil, made a big step forward when, thirty years ago, he cemented a metal-foil window in the bulb of the tube and shot cathode rays through it, and thereby for the first time obtained cathode rays out in the air. Numerous advancements in cathode-ray tube construction have been made by other investigators since then, especially in regard to the output of the tube. In the

research laboratory of the General Electric Company there has now been devised, by Dr. W. D. Coolidge, a tube which is characterized by greatly increased output, much higher operating voltages, and by being entirely sealed off from the exhaust system.

Practical applications for the new tube have not yet been developed, but its very high output has already led to the dis-



DR. W. D. COOLIDGE

covery of phenomena which had not been observed with previous tubes. Such, for instance, are the production of a yellowish solid when cathode rays are passed through acetylene, a colorless gas; and the production of electrical discharges or explosions just beneath the surface layers of many substances. Work with a gray rabbit led to the production of growths of longer and white hair on rayed areas. When the leaf of the rubber plant was similarly

bombarded, latex or milk was exuded. In addition to such results as these, cathode rays, in smaller concentrations, were previously found by other observers to kill germs and spores, cause many salts to become brilliantly fluorescent or to change in color, and to effect physical and chemical changes of different kinds.

Most of the effects are superficial phenomena, however, since the rays have relatively low penetrating power. At 350,000 volts they penetrate more than two feet of air, but in substances of

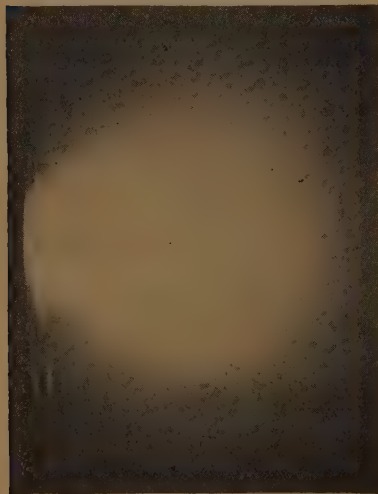
minute holes, and it was difficult to support this thin piece of metal so that it would not collapse when the tube was evacuated. His tube was operated with a permanent connection to a vacuum system, and depended for its operation on the presence of a small amount of gas in the tube. The gas molecules were ionized when a high potential was impressed across the electrodes. The positive ions went to the cathode. The bombardment of the cathode by these positive ions liberated the electrons which constituted the main cathode-ray stream.

In the new tube a current of a few milliamperes, at voltages up to 350,000, may be used. The window has a diameter of eight centimeters, and is of nickel, 0.0254 millimeter in thickness.

The operation of the tube is similar to that of the modern pure electron-discharge X-ray tube, also a development of Dr. Coolidge's, in that the stream of electrons is liberated by a heated tungsten filament and in that a very high vacuum is used. The tube may be sealed off from the exhaust system, and transported and used as easily as an X-ray tube. Connected to the window, or anode, there is a copper tube within the anode arm, serving as an electrostatic shield to prevent puncturing of the glass by the high voltage.

The cathode is a heated tungsten wire from which the electrons come; the anode is a nickel window which is half of a thousandth of an inch thick and which is supported against the atmospheric pressure by a honeycomb structure of molybdenum. Reckoned in inches, the window is thin, but in terms of atomic layers it is thick—500,000 atom layers deep. The window is soldered to an invar sleeve to which the glass of the anode arm is sealed.

The filament is heated with a low-voltage current. Electrons evaporate from the filament at a rate determined by the temperature, which in turn depends upon the filament current. A high voltage is impressed between the electrodes, the electrons from the filament thereby being driven at enormous speeds from the cathode to the anode, through which most of them go into the surrounding air.



THE RAY-DISCHARGES IN AIR

greater density, such as salts, the penetration is correspondingly less.

The power of the new cathode-ray tube is evident in the statement that it produces as many cathode (or beta) rays as does a million grams of radium bromide, but of lower average velocity.

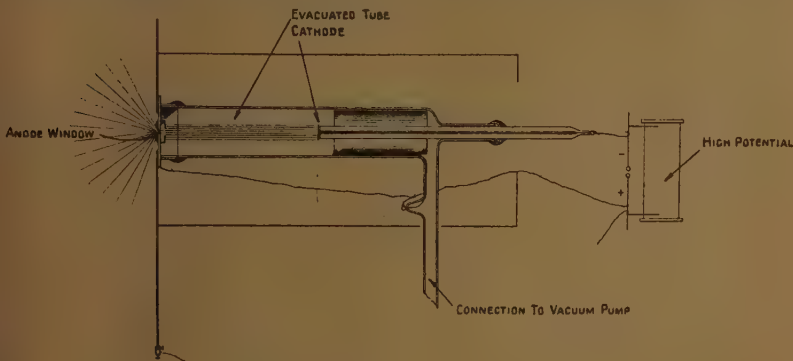
The window of Lenard's original cathode-ray tube was 1.7 millimeters in diameter, of aluminum foil 0.00265 millimeters thick, cemented to a metal plate in the end of the tube. The small diameter was the result of several circumstances. It was difficult to obtain a larger piece of such thin foil without

CAUSES MINERALS TO GLOW

The electrons escaping through the metal window cause the air to assume a purplish glow, extending in front of and for some distance back of the window. This luminous, essentially spherical mass may be as much as two feet in diameter, depending on the voltage, and is due to the ionization of the air by the high-speed electrons. The odor of ozone and the oxides of nitrogen is also noticeable. Impact of the electrons on the window causes a slight production of X rays there, and additional X rays are produced when the cathode rays impinge on other substances outside the tube. In addition to such phenomena as can be

bluish-white scintillations. These have been observed while the crystal is undergoing bombardment and for as long as a minute after raying. By lightly scratching the rayed surface of the crystal with a sharp instrument, the scintillations may be induced for as long as an hour after raying.

The area in the neighborhood of a scintillation loses all of its luminosity as the scintillation occurs, and then appears dark against the bright orange background. Under the microscope the spot is marked by a little crater, with many tiny canals leading from it. Examination of one of these areas with a microscope shows the presence of a fine



LENARD'S ORIGINAL CATHODE-RAY TUBE

visually observed when a substance is placed in the path of the cathode rays, other things are happening. Matter of any kind in the path of the rays becomes heated by the bombardment of the rays and at the same time becomes a source of X rays, just as though it were within an evacuated tube. The general design of the new tube is such that it seems possible to use still larger windows and more energy.

The following experiments were conducted with a cathode-ray tube operating at 200,000 volts.

Calcite crystals, upon being rayed, glow strongly with an orange light and remain luminous for several hours. In addition to this, they may show bright,

network of lines radiating from each explosion crater. Each appears to be a line of small globules, like a string of beads. The reason for this beaded appearance is not fully understood.

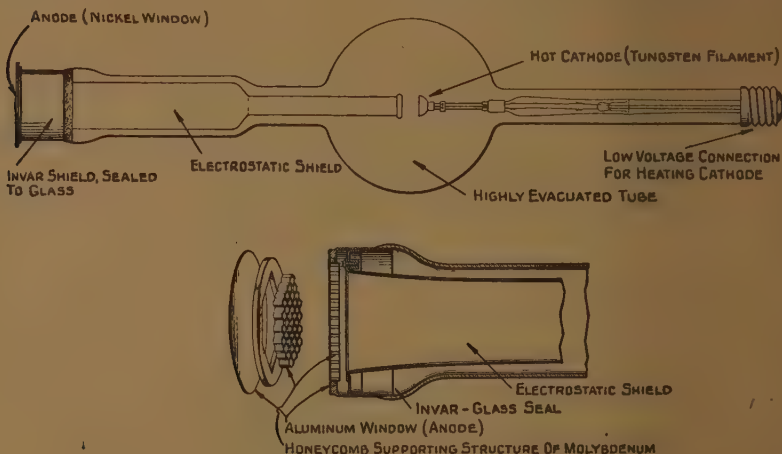
The luminosity of the ordinarily colorless and transparent calcite crystal is weird and uncanny. To the uninitiated the mineral has the appearance of a red-hot coal, and is touched with reluctance. It is cold light, however, in that no appreciable temperature rise is apparent, and the crystal can be handled without danger. The luminosity occurs within a very thin layer since the rays penetrate only about 1/10 millimeter into the crystal structure.

Calcite is not the only mineral which

is caused to glow by treatment with cathode rays. Some glow only while subjected to bombardment, and others continue to glow for some time; and various colors are apparent, according to the minerals used. In the case of granite, a mixture of different minerals, a very beautiful effect is produced by the rays since such colors as orange, blue, red and green become evident. These colors are very brilliant while the granite is under bombardment, and persist less brilliantly for some time thereafter.

colors, it is chilled again with liquid air and allowed to warm up once more, it will display no color until it has reached the previous higher temperature. The screen then glows with the proper color for that temperature. This radiant energy can be stored in the intensifying screen by maintaining a sufficiently low temperature, and can be liberated at any time by the application of heat.

One of the most interesting experiments with the cathode ray has been the production of a solid by passing acetylene gas in front of the window of the



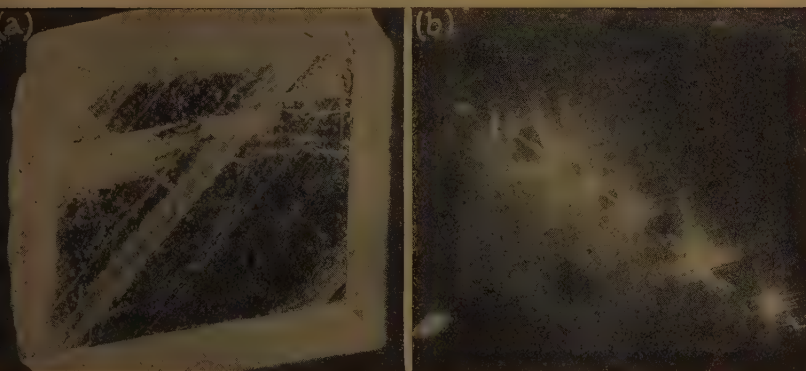
HOW THE NEW TUBE IS ASSEMBLED

INTENSE COLD WORKS WEIRD CHANGES

Fluorescent screens such as are used with X rays are also caused to glow intensely when subjected to cathode rays. A beautiful experiment can be conducted with a fluorescent screen of cadmium tungstate. When subjected to cathode rays it gives off green light and shows very little phosphorescence, or afterglow. If a strip of this screen is dipped into liquid air and is then rayed, it shows, upon warming up, several distinct luminescent periods, each having its own characteristic color, the color depending upon the temperature. If, after the screen has somewhat warmed up and has passed through some of the

tube while it is in operation. The product, similar to or perhaps the same as that obtained previously in minute traces either by a corona discharge in acetylene or by the use of radium emanation, has been produced in gram lots with the new tube.

In producing the compound, the gas is led through a chamber in front of the window of the tube, and the compound is formed immediately. It can be collected as a fluffy, yellow powder, or under different electrical conditions directly as a varnish-like film on metallic or other surfaces, to which it adheres tightly. The powder has been found to be insoluble in all the numerous chemi-



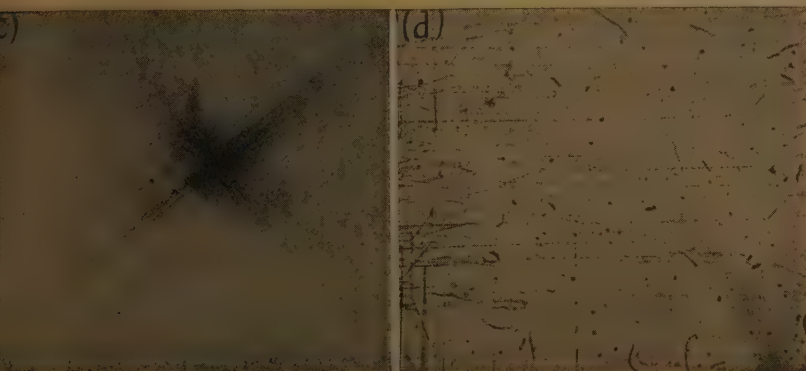
CALCITE SHOWING (A) SPOTS WHICH HAVE SCINTILLATED
(B) SOME SPOTS MAGNIFIED

cal agents that have been tried so far in the experiments.

The high-speed electrons emitted by the tube cause many liquids and solids to undergo marked chemical changes. Just as acetylene is changed to a solid, so is castor oil solidified. Crystals of cane sugar become opaque white and, if heated afterwards, give off considerable quantities of gas. If a solution of sugar in water is exposed to the rays and then tested with litmus paper, it is found that the solution has become acid.

If a shallow dish of ordinary salt is exposed for a moment to the rays, the salt turns brown. By removing the surface layer of salt it is seen that the crystals beneath, not reached by the rays, have not been affected.

If glass is exposed to the rays, it immediately turns purplish or brownish in color, similar to the way glass is affected by long exposure to X rays. By the use of a metal stencil, the glass can be marked with any design, either very lightly or more deeply, depending



(C) SINGLE SPOT CONSIDERABLY MAGNIFIED
(D) 360 DIAMETERS MAGNIFICATION



EFFECT ON RABBIT'S EAR

upon the amount of exposure. Porcelain and crockery can be marked in a similar way.

The color effects produced by these experiments have been found to be more or less permanent. Some colors are lost in a short time, and others continue indefinitely.

Electrical discharges or explosions occur in a sheet of celluloid exposed to the rays at about liquid-air temperatures. These sparks or scintillations are observed in a dark room during and immediately following exposure. Subsequent observation of the celluloid under a microscope will show that just beneath the surface there has been a discharge where each of the sparks occurred. The craters in the celluloid are shown by a microscope not as straight lines of globules, as in the case of calcite, but as very irregular lines, due probably to the fact that calcite is crystalline in structure and celluloid is not.

If the leaf of a rubber plant (*Ficus elastica*) is pricked with a pin point, a white latex or milk is exuded from the

puncture. When a portion of the leaf is rayed with one milliamperere of current for twenty seconds at a distance of one inch from the window, the rayed area becomes covered immediately with the white latex, indicating that the electrons have in some way caused the cell walls to become permeable to the latex.

An exposure of only 0.1 milliamperere for one second causes a color change in the leaf, with subsequent drying out of the rayed area to a depth corresponding to the penetration of the rays.

RAYS ALWAYS UNDER CONTROL

X rays do not kill bacteria, but the 200,000-volt cathode rays do, even with an exposure of as little as one-tenth of a second.

One milliamperere of current for a fraction of a second has been found sufficient to cause immediate paralysis and subsequent death of fruit-flies.

A peculiar effect discovered during experiments with rabbits is that a profuse growth of snow-white hair is pro-



SEVEN WEEKS LATER

duced by exposure to the rays. The ear of a rabbit was rayed with 0.1 milliamperes for 0.1 second over an area one centimeter in diameter. The rayed skin became deeply pigmented within a few days, and the hair came out. Seven weeks later, new hair appeared. This new hair was longer and was a mixture of white and gray in color.

With 100 times the exposure—one milliamperes for one second on a similar area—a scab formed over the rayed area. The scab came off a few days later, taking the hair with it. A profuse growth of snow-white hair started two weeks later, and soon became much longer than the original hair.

In further experiments the exposure was increased to one milliamperes for fifty seconds. Scabs developed on both sides of the ear, and when they fell away a hole was left in the ear. The edge of this hole was at first without hair, but later became covered with a growth of the snow-white hair.

Among the most important of ray-producing devices or substances available for scientific research are radium compounds and similar products. They are constantly disintegrating and, in so

doing, give off alpha, beta and gamma rays. The beta rays are really high-speed electrons, and in this respect are identical with those of the cathode-ray tube, but of higher average velocity.

Radium, however, is uncontrollable in that the experimenter cannot govern the velocity at which the electrons are bombarded into space. The cathode-ray tube offers a source of high-speed electrons, or beta rays, which is at all times under the control of the experimenter, both as to quantity and velocity. Added to this there is the fact that one of the tubes will produce a very high concentration of the rays—one tube releasing as many electrons per second as a million grams of radium bromide.

Much has been learned in the past of the properties of cathode rays by brilliant experiments conducted by numerous investigators. With the new tube—completely sealed, portable, always under control, capable of producing a very powerful stream of high-speed electrons—the field has been opened for conducting experiments previously impossible, and it is to be expected that our understanding of electronic phenomena will be greatly increased thereby.

PERIODICAL NECROLOGY

It is said that the first magazine that really deserved the name was the *Athenian Gazette* which appeared in London in 1691. It was much like the present *Notes and Queries* that is still published there. *Gentleman's Magazine*, starting in 1731, is the real beginning of the monthly magazine such as we know it in recent years.

In this country Boston and Philadelphia were early centers of magazine publishing. The *North American Review*, started in Boston in 1815, destined to be as famous as its British prototypes, the *Quarterly Review* and the *Edinburgh Review*, which started some ten years earlier. The *Massachusetts Magazine* of 1789 and Carey's *American Museum*, published in Philadelphia in 1787, are interesting early examples of American magazines. In 1820 *Godey's*

Lady's Book started and was famous for many years for its fashions, and the prints are still eagerly sought by collectors who use them for tray and lampshade purposes. *Harper's Magazine* was born in 1850; *Atlantic Monthly* in 1857; *Scribner's Magazine* in 1873, and soon after the deluge of modern magazines started, about seven thousand being now listed in the latest volume of *Ayer's Newspaper Annual*.

According to *Ayer's Newspaper Annual*, last edition, the births in the periodical field, including newspapers, were last year 952, while the mortality during the same year was 942, an interesting sidelight on the great number of changes in a year where the total publications varied only ten titles.—*American Library Association*.

NEW ELEMENTS

ILLINIUM AND OTHERS

Nature builds up her most complex forms of matter out of simple units which are known as elements. Many of the things which we use most commonly in our daily life are elements in a simple form. Among these useful elements are the metals, such as iron, copper, lead, zinc, aluminum and silver. In addition, the elements carbon, sulphur, oxygen, phosphorus and chlorine are among our most useful everyday substances. By far the largest number of substances which we use, either directly or indirectly, in the course of the round of our daily habits, are compounds which are formed by the union of two or more elements.

Among the common and widely used compounds are water, salt, sugar, essentially all our foods, fabrics for our clothing, building material for our homes, all plant and animal tissue—in fact most of the objects about us. Some of these compounds are simple, as for example, the ordinary table salt which we season our food, which is composed of the two elements sodium and chlorine in an equal number of units or atoms. Water is composed of hydrogen and oxygen, there being twice as many atoms of the former as of the latter. Sugar is more complex; in fact to the chemist the name sugar refers to a large group of compounds, of which the most familiar is the usual table sweetening material called cane sugar or sucrose. Its simple unit, called a molecule, contains twelve atoms of carbon, twenty-two atoms of hydrogen and eleven atoms of oxygen. While this seems complex when compared with salt and water, it is really extremely simple when compared with many other compounds such as those used as dyes or as drugs.

While the number of compounds is enormous, the number of elements used to build up these compounds is definitely limited. Within the limits of our senses as they are now able to function, scientists are convinced that there are ninety-two elements possible. Students of the

future may be able to extend the present bounds of knowledge into regions of whose existence we are entirely ignorant at present, but in the light of our present information, hydrogen is the lightest atom which can exist, and uranium is the heaviest. Within these limits science declares that there are ninety-two elements possible and no more.

BRILLIANT PHYSICIST KILLED IN WAR

When the elements are arranged in the order of increasing atomic weight, it has been found that at regular intervals similar properties are repeated. By writing the abbreviations for the elements in such a manner that those with similar properties fall in the same vertical column, the entire list of elements is divided into a series of groups whose similar properties indicate clearly that they are fundamentally related. Because of the periodic recurrence of properties in this manner such a table is known as the Periodic Table. A simple form of the table is shown on page 33. The atomic number which indicates the position of each element in the series, precedes the abbreviation or symbol of each element. The atomic weight is shown underneath in lighter type.

The method of determining the total number of building blocks which Mother Nature has carefully used in making up that part of the universe which we know, is interesting. It depends upon a principle discovered by the brilliant young British physicist, H. G. J. Moseley, just before the outbreak of the World War. When the war broke out Moseley enlisted, and his death during the disastrous campaign at Gallipoli was one of the severe scientific tragedies of the war. The discovery of Moseley involved a new use of the X-ray tube, one form of which is familiar because of its use by physicians and dentists.

An X-ray tube consists of a highly evacuated tube, so arranged that a powerful stream of electrons is shot off from the cathode and brought to a focus on

a target as shown on page 23. From the target there radiates a system of X rays which consist of electromagnetic pulsations somewhat similar to the waves which produce the colors of the rainbow, except that the distance from the crest of one wave to that of the next, the wavelength, is vastly shorter. There are whole series of such waves, as shown on page 22, the effect produced depending upon the wavelength. The short wavelengths give us X rays; longer lengths produce waves similar to light except that they are not visible to the human eye. These are known as ultra-violet waves. They are known to affect a photographic plate markedly and they also have exceptional influence on health and nutrition. Beyond the ultra-violet we have the visible spectrum from the violet through the so-called primary colors to red, the longest waves which can be detected by the eye.

Scientific instruments are able to detect waves longer than the red, which are spoken of as belonging to the infra-red region. Far beyond these come the electromagnetic pulsations known as the radio waves. These waves may be very long, even as long as ten miles from one crest to another, although the usual length used in broadcasting is a quarter of a mile or less. So it is to be noticed that X rays are like these other forms of radiations, except that they are extremely short, powerful and with high penetrating power.

The contribution made by Moseley that has been of such great value in studying Nature's simplest forms of matter is that the wavelength of the X rays may be made to reveal the nature of the substance on the target. He found that when any particular element was placed on the target it gave rise to X rays which were characteristic of this element alone. When the elements were taken in the order of increasing atomic weight, each produced X rays whose wavelengths differed from those of its neighbors. If these lines are arranged uniformly with respect to some known reference line, then succeeding elements show a gradual and uniform shift in the position of their characteristic lines. Such a series if drawn in a diagram, with the lines of adjacent elements

touching, will form a well-defined series of steps. If all the elements were included in this plan, there would be a continuous stairway with one step for every element.

Not all the possible ninety-two elements are known at the present time. The scheme of X-ray analysis, for which we are indebted to Moseley, makes it possible for us to tell exactly where in our series of elements there is one member missing. Thus, it will be observed in the table on page 33 that there appears to be a double shift as we pass from the element titanium, whose abbreviation is Ti, to the element calcium, represented by Ca, leaving one step missing in the stairway. In this case the element omitted in the figure is known, it being the rare element scandium. But in case there is a double shift at some point where no element is known, then it seems reasonable to suppose that there is somewhere on earth an undiscovered element which fits into this so far unoccupied space.

In every case where X-ray spectrum analysis indicates that there should be an unknown element, it is found that the Periodic Table makes necessary a similar conclusion. At these points, if succeeding known elements are placed together in a regular position, the later members fail to fall into such closely related groups. But, if at such places a blank space is left on the supposition that someone later may discover an element for this place, then the regular sequence is continued and like elements fall into their regular family groups. Whenever both the Periodic Table and X-ray spectrum analysis agree in indicating that an element is missing, there is little doubt in the minds of scientists that such an element must exist.

Studies of this kind led the scientists of 1923 to the conclusion that there were five missing elements within the known limits of our table. Two of these unknown elements Numbers 43 and 75, were considered similar to manganese, Mn, because they were placed directly under this element. The third missing element, Number 85, fell in the same vertical column under iodine; another is Number 87 under the rare element caesium, and the last, Number 61, be-

longed to that peculiar group known as the rare earths. This is a group of fifteen elements of such similar properties that they are most conveniently indicated as occupying a single space in the table. The individual members of the Rare Earth group are shown at the lower part of the table. Element Number 61, the fifth member of this group, was counted among the missing elements until recently.

phorus in 1738. Then discoveries came more rapidly. Many of these discoveries were made simultaneously in different countries, and some are still in dispute, so it is impossible to credit a definite number to each nation, but it is sufficiently accurate to say that twenty-five of the elements known in 1923 have been discovered in England, while Germany and Sweden may each be credited with seventeen, France with



DR. B. S. HOPKINS IN HIS LABORATORY

We have no idea when or where the first chemical element was discovered. It is certain that primitive man began early to use such of the chemical elements as were available, although of course there was at that time no distinction made between elements and compounds.

The first recorded discovery of chemical elements was made in 1450 by Basil Valentine, a noted German alchemist, who found the elements antimony and bismuth. Zinc was discovered in 1520, arsenic in 1699, cobalt in 1733 and phos-

fourteen, Austria with three, and Switzerland, Russia and Spain with one each.

The search for new elements has always been a fascinating task. In the early days the search was largely a blind one, discoveries frequently being made by mere chance. As the number of undiscovered elements grew less the search became more difficult, but as knowledge increased, the efforts of the searchers were directed by the predictions based on theory and experience. When it was recognized that the number of undiscovered elements was decidedly limited,

the search became more exciting as chemists approached the point where they believed there would be no more elements to be discovered.

FOLLOWING A "WARM" TRAIL

Armed with apparatus for measuring accurately the X-ray spectrum analysis, and guided by theories derived from the Periodic Table and recent knowledge concerning atomic structure, the modern search for missing elements leaves little to chance. Moseley's X-ray methods indicate what elements are missing, the Periodic Table shows what properties and what relationships the unknown element must have, and this in turn indicates in what native environment the unknown must be hiding. So the discovery of a new element becomes the supreme test for certain chemical theories and the accuracy of scientific reasoning.

Many of the recently discovered elements have been located by just such methods. After the discovery of argon and terrestrial helium, it became evident that there should be other inert gases in the atmosphere, one light in weight between helium and argon, and at least two heavier gases, all of which should be chemically inert. Sir William Ramsay in England secured a large quantity of liquid air, and from it he separated for the first time the light gas neon, and the heavier ones, xenon and krypton.

In 1911 Professor Urbain in Paris separated from some rare earth material a substance which showed new properties and apparently contained a new element. On account of the war there was a delay in applying the methods of X-ray analysis, but in 1922 this was done and the result seemed to indicate that a new element, Number 72, had definitely been located. The name *celtium* was applied to the element, which was regarded as a member of the Rare Earth group because of its origin.

From purely scientific reasons Professor Bohr in Copenhagen reasoned that element Number 72 could not be a member of the Rare Earth group but must belong in Group IV, which would indicate its very close relationship to zirconium. Accordingly he suggested to

his countryman, Professor Hevesy, that he examine some zirconium ores for evidence of the presence of element Number 72. When this was done, unmistakable evidence of the presence of this element was found in the mineral zircon. The name hafnium was given to the element, on the assumption that Urbain was mistaken. Immediately a controversy arose, each claiming the right as discoverer to name the element. It is impossible at this time to decide the dispute finally, for it seems quite within the range of possibilities that both men found the element under different environments. Certain it is that both men did some exceptionally accurate and skilful scientific work in applying to their problem the best of our modern scientific theories.

Reasoning from the relationship shown in the Periodic Table, Professor Noddack and his associates at Berlin concluded that elements Numbers 43 and 75 ought to resemble manganese in some respects but they should differ from it in others; they should also be related to columbium and tantalum. Searching in material containing these known elements, there was separated a small quantity of a substance which gave X-ray lines of the correct wavelength for these elements. Accordingly, early in 1925 announcement was made of the discovery of these two elements, which were named *masurium* and *rhenium*, respectively. The existence of the latter in ordinary salts and ores of manganese has been shown by Druce and Loring in London, and by Heyrovsky in Prague. Recent work at the Platinum Institute in Russia has failed to confirm these results and so these two elements must still be considered doubtful.

The most recently discovered element is the one announced by the University of Illinois in March, 1926. This is element Number 61, the missing member of the Rare Earth group, to which the name "*illinium*" has been given in honor of the state and the university in which the work was done. The actual search for the element occupied about five years' time, the problem being extremely difficult because of the exceedingly complicated mixtures in which these rare earth elements are found.

In the manufacture of mantles for use on our gas jets, large quantities of the mineral known as monazite are imported annually from India and Brazil. This mineral is very complex, the most valuable component being thoria, which comprises from four to ten percent of the ore. Thoria mixed with a little ceria is the material used in the gas mantles. There is very little use in normal times for the rest of the monazite after the materials for the manufacture of gas mantles is removed, so usually this residue is thrown away. It consists of a very complicated mixture of the salts of the rare earths. Prominent among these are the elements neodymium, Number 60, and samarium, Number 62. Our theories lead us to the conclusion that between these two elements there should be another, Number 61. The fact that unsuccessful search had been made for this element in several of the world's best laboratories may indicate that it is probably one of the most rare of the Rare Earth group.

The most common method of separating the members of the Rare Earth group from each other is known as fractional crystallization. This is based on the fact that the salts of these elements differ among themselves in their solubility in a solvent such as water. The process is carried out by preparing a saturated solution at an elevated temperature and then allowing it to cool. Usually this causes a part of the salts in solution to crystallize out, and it is natural to expect that those salts which are least soluble will crystallize first. When this process is repeated many hundreds of times the less soluble salts are partially separated from those that are more readily soluble. Such work requires long, patient effort and it is obvious that the separations obtained by such methods can never be definite and sharp.

The usual process of fractional crystallization which is used for separating elements near neodymium and samarium, is the double magnesium nitrate which separates these elements in the order of their atomic numbers. This brings the element illinium between

neodymium and samarium, both of which are relatively abundant and have a persistent habit of obscuring other closely related elements. Consequently it is particularly difficult to detect the scarce element illinium when it is surrounded by neodymium and samarium. It is quite probable that this explains why the element escaped detection for so many years.

When fractional crystallization is carried out with the use of the bromates, the order of crystallization is changed materially. Neodymium goes into the more soluble fractions while the elements terbium and gadolinium separate illinium from neodymium and samarium. Neither terbium nor gadolinium are troublesome about obscuring the presence of other elements which may be present in their solutions. As a consequence, the detection of illinium is more easily made in bromate solutions than in the double magnesium nitrate solutions. But the final proof of the existence of the new element, must of course be made with the X-ray spectrum. This work has been done with the location of two lines which are believed to be produced by atoms of illinium.

If further investigation confirms the conclusions drawn from the evidence already obtained, then we know ninety of the possible ninety-two elements. Search is being made for the two missing elements, Numbers 85 and 87, and the announcement of their discovery may be expected at any time. It is quite possible that unusual difficulties may be encountered in the search for these elements since it seems quite probable that they are radioactive elements which may be subject to very rapid decay. We must await further study along this line, which is fascinating but difficult.

When these two stragglers are added to our list of known elements then our table of Nature's building blocks will become complete.—*B. S. Hopkins, Professor Inorganic Chemistry, University of Illinois.*

See also Vol. I, pages 155-157, Vol. II, pages 24-28.

THE YEAR IN CHEMISTRY

The Lancashire farmer who put a setting of "fresh country eggs" under one of his hens recently had no idea of indulging in research, but his result, a crop of lusty young alligators, is really no more striking than some of the industrial developments of the past twelve months in America. Seeking a new pulping process, a paper maker has been led to a cellulosic material suitable for almost every purpose but paper. A prospective manufacturer of ammonia from waste hydrogen has found himself embarked upon the strange sea of organic solvents by the discovery of a new, highly profitable synthesis of methanol. An importer of rubber latex, attempting to widen his market, has been pushed into an extensive program of manufacture of shoe soles. Similar though these results are to the farmer's alligators, the industrialists are not puzzled, as the farmer was, by the question, "what country?" They know that the answer is to be found in research, thoughtfully initiated and courageously prosecuted.

More and more the inescapable necessity of constant watchfulness, of the alert industrial brains of research, is being impressed upon the business minds of America. One by one the ultra-conservative corporations, who a decade or so ago sneered at the thought of learning anything valuable from science, are including in their budgets generous provisions for the establishment and maintenance of effective research organizations. The reclusive age of trade secrecy in this country is rapidly passing, and in its place an era of active research is assisting progress through mutual industrial confidence. The beginnings of fundamental research in industry are still fresh in the minds of many who have seen its influence spread throughout our economic fabric. So frankly open are American industrialists that foreign guests at the Institute of Chemistry of the American Chemical Society were amazed at the freedom from restraint which characterized its discussions of matters upon which foreign chemists would have been forced to preserve a complete silence.

U. S. STEEL CORPORATION INAUGURATES RESEARCH

The initiation of a huge research organization to study the fundamental problems of the steel industry is probably the best indication one could have of the American adoption of research as a business necessity. The United States Steel Corporation, one of the most conservative of American businesses, has very recently appointed John Johnston, formerly of Yale University, to organize and direct its research activities. The program for this work is still being laid out, but the direction and support to be given the movement assure its successful outcome.

INSTITUTE OF CHEMISTRY OF THE AMERICAN CHEMICAL SOCIETY

Probably the experiment performed during the year which gives promise of the most far-reaching effects was the holding of the first Institute of Chemistry of the American Chemical Society at Pennsylvania State College during the month of July. This movement can only be characterized as an experiment, but its success justifies the hope of further results of great importance to the American economic structure. The idea of holding such a meeting is the logical development from past experiences of the society at its own meetings and at the Institute of Politics at Williamstown, Mass., last summer. Its design was to provide opportunities for the leisurely discussion of important scientific and industrial topics under conditions as nearly resembling those of a vacation as possible. The program included daily conferences on important subjects, regularly outlined courses of study appealing to those seeking university degrees, and a number of other features, such as lectures and motion pictures. This program was carried out in a session extending through four weeks amid ideal vacation surroundings. Its success is indicated by the enthusiastic attendance of nearly four hundred chemists during all or part of the four-week period. Although it was expected

that the personnel of the Institute would show an overwhelming predominance of academic people, the roster, with 53 per cent of its names connected with industry, demonstrated the keen interest manufacturers feel in the development of fundamental as well as industrial science. Certainly this first experiment has fully justified continuation of the idea, and it is planned to hold a similar meeting during the summer of 1928 at Northwestern University, Evanston, Ill.

RUBBER

Operation of the Stevenson Act:

Rubber and the operation of the Stevenson plan of curtailing exports of crude from producing countries has been much in the public eye. The formation of a pool by American rubber consumers to provide capital to impound crude rubber in times of low prices and to release it as prices rise has been much discussed, although nothing definite has yet been accomplished. The provisions of the Stevenson act to curtail exports when crude prices drop has operated to encourage violent fluctuations in the rubber markets, as demand has changed more rapidly than supplies could be brought to consumers. This buying pool, with a capital of approximately \$40,000,000, is intended to store rubber in easily reached warehouses from which supplies might be released quickly to prevent rapid rises of price and into which low-priced rubber might be put to prevent sudden drops in value.

Liberian Development: Reports from the development of rubber-growing in Liberia have been most encouraging. According to Harvey S. Firestone, Jr., the plantations of rubber there now contain more than 200,000 mature rubber trees which are yielding rubber at the rate of 100,000 pounds monthly. The general conditions in Liberia are reported to be very favorable for growing rubber, and Mr. Firestone has expressed the belief that ultimate developments in this new field will put an end to foreign domination of the rubber market.

Planting: In addition to the Liberian development, the suggestion has been made by Samuel Wierman that a voluntary consumers' tax of a fraction of a cent a pound of rubber used would pro-

vide sufficient capital for the development of plantation rubber in the Western Hemisphere. This suggestion would involve the planting of several groups of trees at various points in tropical America from which economic conditions could develop plantations large enough to be important factors in supplying American markets with rubber. The feasibility of growing rubber in many locations within comparatively short distances of American markets could thus be demonstrated without undue risk to invested capital. The importance of the objects to be achieved would fully justify the expenditures necessary to conduct the experiments. The interest of Thomas A. Edison—a member of the American Chemical Society—in producing rubber in America has received wide publicity.

Synthesis: Within the year active research on the problem of synthesizing rubber from petroleum derivatives has been vigorously prosecuted. Progress in this direction has not yet gone far enough to warrant detailed statements, but the contributing chemistry of petroleum is advancing so rapidly that there can be no serious question of the adequacy of the raw materials required should rubber synthesis prove practicable.

Use of Latex: The use of rubber latex in small quantities in the strengthening of paper and pulp products received some attention a few years ago as a result of announcements of tests made in Britain. The object at that time was to increase the strength of paper without seriously altering its other properties, and only comparatively small amounts of latex were added to it in manufacture. The results showed some promise, but the increased strength imparted to ordinary paper for printing purposes, for instance, was not sufficient to justify the additional expense involved. In this country development has gone much farther, some material being manufactured on a large industrial scale, although details are as yet not available for publication.

Electroplating: The process of electroplating rubber from latex or colloidal emulsions of reclaim is being developed on an industrial scale at Akron, Ohio,

by American Anode, Inc., and in England by Anode, Ltd. These companies were formed by the Eastman Kodak Co., the B. F. Goodrich Rubber Co., and Anode Rubber Co., Ltd., of Great Britain. Definite information about their activities has been very meager.

PETROLEUM

The chemistry of petroleum has advanced to the point of manufacture of two new products on a commercial scale. Amyl alcohol, derived from pentane by chlorination and subsequent hydrolysis, is being produced at a rate of more than 100,000 gallons per month, using casinghead gasoline as the raw material. A denaturant for alcohol to replace pyridine is being made by the oxidation of petroleum distillates and is meeting with wide acceptance under the trade name Aldehol.

Amyl Alcohol from Pentane: The synthesis of amyl alcohol from pentane yields a mixture of five isomers which is obtained commercially in high purity. By converting this mixture of alcohols to the corresponding acetates, a solvent of particular value in lacquer manufacture is produced. The manufacture of these materials directly from the hydrocarbon is leading to a more careful study of the possibilities of such syntheses, and it has already been demonstrated that pentadiene, required for rubber synthesis, can be produced in larger quantities in a somewhat similar manner. The increasing knowledge of the properties of petroleum hydrocarbons that is being gained in this way leads to the belief that further developments will yield extremely valuable results.

Aldehol from Petroleum Distillates: Prohibition, with its increasing requirements of satisfactory denaturants, has stimulated another use for petroleum through chemical treatment. The growing demand for pyridine as a denaturant forced prices up to such an extent that the denaturers of alcohol urgently sought relief, and as a result the use of an oxidized petroleum distillate to replace high-priced pyridine was authorized. Whether this new industry of making a denaturant from kerosene will

lead to further developments of importance is difficult to surmise, but a flourishing industry in this field already exists. It produces a mixture of hydrocarbons, aldehydes, alcohols, and other oxidation products of petroleum, which possesses a very disagreeable odor and which gives prompt warning of its presence in denatured alcohol. For this reason, and on account of the difficulty of separating it from the alcohol, the new denaturant, Aldehol, has admirably served the purposes for which it was intended.

It is interesting, if not particularly important, that chemical industry achieved a five-column headline in one of New York's tabloid newspapers last fall by virtue of the fact that Oom, the Omnipotent, was found to be connected with the company formed to manufacture Aldehol. Oom, the Omnipotent—in private life, Pierre A. Bernard—is the head of a peculiar cult which has been much in the public eye with its strange doings in the last few years.

Gases from Cracking Stills: The elaboration of the gases from cracking stills has encountered a rather serious obstacle in the difficulty of removing all disagreeable odors from finished products. On this account, progress in this direction has been extremely slow.

Crude Oil Production: Crude oil production has been increasing at such an alarming rate that serious steps are being taken to remedy the situation. Five new fields were brought in early in the year, and their production so upset the economic balance of the industry that a possible panic in oil was threatened. In this situation the joint efforts of the Federal Oil Conservation Board and the American Petroleum Institute were put behind a policy of curtailing production, and the outcome ultimately may be the logical operation of oil pools as units. Difficult as the situation has been for the petroleum industry, such a result would be well worth the trouble in assisting the conservation of oil reserves. Actual accomplishment in curtailing the output of existing wells has been slight, but the moral effect of the move has been a decrease in new wells brought in.

LIQUID FUELS FROM COAL

Hydrogenation of coal to produce liquid fuels resembling petroleum has reached a point of commercial application in Germany, and recent announcements state that American rights to the Bergius process have been acquired by the Standard Oil Company of New Jersey. The process consists in treating pulverized low-grade coal with hydrogen under heat and pressure. There is some disagreement as to whether a catalyst is necessary to the operation, one claim being that none is added, and the other that the ash of the coal itself serves this purpose. Its object is an increase in the relative proportion of hydrogen to carbon in the fuel which puts it into the liquid from the solid state. The economic importance of the process in the United States is not at present great, and no statement is on record that it will be put into operation in the near future. Certainly, however, it provides a means of utilizing our large coal reserves to meet any possible deficiency in crude oil and its purchase by a large oil company indicates its potential value in this field.

MOTOR FUEL CONSERVATION

The conservation of motor fuel by special modifiers to adapt it to use in high-compression engines has gone ahead during the past year. Antiknock fuels of several varieties based upon added constituents, such as tetraethyl lead in gasoline, and upon the presence of unsaturated hydrocarbons in cracked gasoline, are to be had at almost any filling station in the country. It is quite possible for the driver of a high-compression engine to set out in his automobile from Maine and travel to Southern California, or from the state of Washington to Florida, without fear of being caught where he cannot buy a satisfactory fuel. This wide distribution of antiknock fuels has made practicable the introduction of high-compression engines into stock automobiles. At least two manufacturers of automobiles now offer cars equipped with high-compression engines and others are rapidly following suit. The advantages to be gained by the motorist through these improvements are a considerably lower

cost of fuel per mile of travel and a greater power output from a motor of a given size and weight. Motorists not so fortunate as to have high-compression engines in their cars are being provided, by one manufacturer, with new cylinder head blocks, so built as to increase the compression ratio of an existing engine to a satisfactory extent. Motors with present compression ratios—i. e., less than five—seem doomed to obsolescence in a short time.

Tetraethyl Lead: Contributing especially to these new fuel economies have been the wide adoption of tetraethyl lead as an antiknock and improved methods of refining cracked distillates to make them conveniently useful in the new type of engines. The mechanism of the cylinder reactions which cause engine knocks and of the modification of these by such special fuels to prevent knocking, even at much higher than ordinary compression ratios, is still the subject of active research in many laboratories. No universally valid theory has yet been advanced, and each investigator has been inclined to promulgate a theory of his own to explain his observations. The methods of investigation used include ultra-violet spectroscopy, analysis of the gas mixture in the cylinder of an operating engine at various points in the explosion cycle, and experiments with pure chemical individuals as fuels. One of the surprising results of research on this problem has been the discovery that pure straight-chain hydrocarbons of the type supposed to be the principal constituents of gasoline cause much more violent knocking than gasoline itself. Some of the isomeric branched-chain hydrocarbons of approximately the same boiling points act as powerful knock preventers. For instance, pure normal heptane produces violent knocking when used as a motor fuel in an ordinary engine, while the octane obtained by reducing the condensation product of two molecules of tertiary butanol can scarcely be made to knock. It would thus seem that the accepted theory that gasoline is made up principally of straight-chain hydrocarbons is erroneous. As a result of these investigations, it has been proposed to prepare a standard antiknock fuel by

mixing normal heptane with the octane mentioned in such proportions as to duplicate the characteristics of any desired fuel. Such a standard would provide a method by which different investigators could obtain comparable results, as it would eliminate all variables except the fuel itself.

Equilibrium Mixtures: The characteristic of lubricating oil in automobile engines to take up gasoline and so dilute itself beyond a useful point has been carefully studied during the year. This tendency to dilution now requires the wastage of large quantities of lubricating oil, apparently needlessly. The Standard Oil Company of Indiana investigated this question rather fully, and found that most oils reach a condition of quasi-equilibrium when mixed with the proper proportion of volatile motor fuels. Utilizing this fact, they developed an oil mixture, already diluted to a point approaching equilibrium, whose viscosity and lubricating properties remain virtually unchanged during a much longer period in the automobile engine. Naturally, the methods of operation and external temperature control the composition of this equilibrium mixture, and it is hence necessary to provide special oils for each general climatic condition. By producing such an equilibrium mixture of a very heavy oil with a light motor gasoline before its introduction into the engine, the life of the oil in use is extended several fold. The equilibrium reached is not an absolute one, but such a mixture changes much more slowly than an ordinary undiluted oil.

AMMONIA SYNTHESIS

Nitrogen fixation by the ammonia synthesis process has reached the point in the United States where this is a cheaper source of nitrogen for many purposes than Chilean nitrate. Nitric acid can be made by the oxidation of ammonia much more cheaply than from sodium nitrate at present prices. Small units for oxidizing ammonia are being installed in chamber sulphuric acid plants to replace the customary niter pots. This change is resulting in considerable economies in sulphuric acid manufacture. Already the prediction is freely made

that even the removal of the Chilean export tax on nitrate would not reduce the price sufficiently to enable it long to compete in the American market. Announcement during the year of methods of refining nitrate from caliche more cheaply than those now in operation caused a temporary stir, but the increasing output of synthetic ammonia at decreasing prices apparently indicates that synthetic ammonia has little to fear from this direction. The Allied Chemical and Dye Corporation have announced their intention to establish at Hopewell, Va., the largest American plant, but details have been withheld.

The most interesting development in this field during the year has been the adaptation of processes for methanol synthesis to the removal of carbon monoxide and carbon dioxide from the nitrogen-hydrogen mixture before it goes to the ammonia catalysts. The Commercial Solvents Corporation, to utilize a mixture of approximately equal volumes of hydrogen and carbon dioxide obtained as a by-product of its fermentation operations, has developed a process for converting the mixture directly to methanol. Lazote, Inc., is utilizing the methanol reaction to remove carbon monoxide from the nitrogen-hydrogen mixture obtained from the water-gas reaction before using it in the Claude ammonia converters. The increased purity of the gas mixture thus obtained and the value of the methanol produced make the purification a profit-producing operation instead of a mere expense, and thus the cost of ammonia synthesis has been somewhat reduced.

SYNTHESIS OF HYDROCARBONS

Much interest has been aroused by the announcement from the Kaiser Wilhelm Institute for Coal Research of the synthesis of hydrocarbons of a very high molecular weight by a catalytic reaction between carbon monoxide and hydrogen at pressures as low as one atmosphere. In this way Fischer and Tropsch have prepared hydrocarbons comparable to those present in paraffin waxes melting as high as 120° C. The catalysts used are not completely disclosed, but a statement is made that they contain metallic iron and alkaline earth oxides. From

the results obtained, these two investigators advanced a theory that petroleum was formed geologically by a reaction similar to their own. This theory of the formation of petroleum is the only one so far advanced by which it can be supposed that petroleum is still being formed in nature. Gas mixtures and catalysts required for this synthesis are to be found in volcanoes and elsewhere in nature so that there seems to be some ground for acceptance of such a theory.

NEW USES FOR CARBON DIOXIDE

Refrigeration: Solid carbon dioxide as a commercial refrigerant has reached the point of competition between two manufacturers of sufficient importance to justify three infringement suits in the federal courts to pass upon the validity of the patents issued. Production of this refrigerant in three plants during the past summer reached a daily total of about fifteen tons, thus indicating that it has passed somewhat beyond the large experimental scale of a year ago.

Fire Extinguisher: Carbon dioxide has long been known to be an efficient fire extinguisher but the aspirating action of a current of the gas has prevented its successful use until recently. A modification of the ordinary cylinder for liquid carbon dioxide and a specially designed nozzle for throwing it on the flame yields a very cold mixture of solid and gas having a high efficiency in extinguishing fires, particularly of oily materials. The device for using solid carbon dioxide in this way has proved itself highly effective and extremely simple to operate. There can be no possible danger of the contents of such an extinguisher freezing, and it is always ready for use, even in the most extreme weather.

These widening uses for carbon dioxide justify careful search for more economical methods of recovering it from flue gases.

ALLOYS

The vogue of long-distance flying during the past few months has brought seriously to attention the fact that light metal alloys have not yet been developed with strength characteristics superior to those of alloy steels. In spite of the

lightness of alloys of aluminum, magnesium, etc., their strength per unit of weight is still much lower than that of some of the special alloy steels which have been widely used in the strength members of modern airplanes. Much is being done along the line of producing light strong alloys but many opportunities remain to be seized.

Chromium has maintained its place in the interest of technical men, and its use as an electrodeposited protective coating has increased somewhat, although real progress has been hindered by patent complications. From time to time mergers of the parties in interest have been rumored, and until some consolidation of patent interests takes place further development will be slow.

Chromium-bearing iron and steel, on the other hand, have enjoyed special attention, largely because of the increase in the number of ammonia-oxidation units and nitric-acid plants. The chemical industry is indebted to the Du Pont organization for its extensive pioneer use of these new chromium-iron alloys in the chemical industry where, as well as in other industries, they seem destined to serve in many special ways.

UTILIZATION OF CELLULOSE WASTE

Cornstalks: In the field of cellulose chemistry several developments merit attention. The one which has been most in the public eye, and which in its present state is probably least deserving of serious general attention, is the development of the so-called Dorner process for recovering alpha cellulose from cornstalks. This process, devised by an Austrian chemist, has been imported into this country and a few small-scale experimental runs have been made. It is based upon cooking in comparatively dilute soda solutions. Conflicting reports as to the quality of the product followed a very optimistic public announcement of the process. Its promoters claimed to have obtained yields of 33 to 35 percent pulp on the weight of the cornstalks used, and further stated that this product showed an alpha-cellulose content of about 95 percent. On this basis they proposed to use the process to supply raw material for rayon manufacture. Independent ana-

lysts have been unable to confirm the very high alpha-cellulose content claimed and believe, on the basis of their analyses, that the hope of using this in rayon manufacture is ill-founded. The results of large-scale experiments with this process are awaited with much interest. Certainly the present status of the proposition leaves much unproved. It is understood that its promoters plan reasonably large-scale semi-plant runs this autumn and that their successful outcome would be followed by the erection of plants in the farm belt to utilize this agricultural waste.

Redwood Forests: Wastes in the redwood forests of the West have been shown to be available for paper manufacture by large-scale plant operations. Plans are on foot for erecting a paper mill to utilize the waste of a large redwood saw-mill of the Pacific Lumber Co., at Scotia, Calif., to make paper and pulp board. This operation has passed successfully through the experimental stage.

Saw-Mill Chips: A third process for utilizing cellulose waste is similar to the process used in puffing grains to convert them into breakfast food. The Mason process, now in operation at Laurel, Miss., consists in subjecting chips to a steam pressure of 1,000 or more pounds per square inch and suddenly releasing this pressure. It yields a cellulose material in which the fibers are almost completely separated. These may be felted and pressed into boards having a high insulating value and a tensile strength of as much as 4,000 to 5,000 pounds per square inch in any direction. Unfortunately, the material has not proved suitable as a paper pulp, but the possibility still remains that modifications of the method may yield a material suitable for this use.

REFORESTATION

Progress toward a more satisfactory pulp-wood tree for reforestation is indicated in a recently issued report of a serious investigation of the hybridization of poplars. In 1924, a research looking to the production of fast-growing trees for pulp production was initiated by the research department of the Oxford Paper Company with the co-

operation of the New York Botanical Garden. A preliminary report of the first three years' work indicates that much may be accomplished in this direction. Careful cross pollination of different varieties of poplars has been carried out with the production of very fast-growing hybrids. Although results so far obtained cannot be considered conclusive, there is reason to believe that much may be accomplished by applying such hybrids to the solution of the problem of reforestation. At present, deforestation is proceeding at a rate four to six times that of the growth of new trees. Any faster growing pulpwood tree would aid greatly in reducing this differential, and it seems highly probable that hybrids of the type sought may yield this much-to-be-desired result.

VITAMINS

Work on vitamins has been progressing rapidly in many parts of the world, but the consensus of opinion of those best able to pass upon the situation seems to indicate that the point has not yet been reached where positive results can be obtained. Announcements by various investigators of the isolation of one or another vitamin in a very pure form have been too indefinite to allow the duplication of their results elsewhere. Knowledge of these essential food constituents is certainly being increased, but one must be bold, indeed, to assert that we are yet approaching the solution of the problems they present. The correlation of findings by different investigators and the formulation of a theory or theories to fit all the facts are still tasks to be done. Several investigators have found that vitamin B, so called, is really not a single substance but a mixture of at least two, and there seems to be some indication that still a third vitamin may also be present in the mixture. This situation, which others have sought unsuccessfully to confirm, is characteristic of the present state of research in this very important field. One must be very slow to state definitely anything on the subject of vitamins. Certainly the probability has been shown that the term "vitamin" as designating an amino body necessary to life is of only limited application, for it is pos-

sible to produce the effect of a vitamin by irradiating ergosterol, containing no nitrogen, with ultra-violet light. Just what the changes are no one knows, but certainly the antirachitic vitamin is produced.

PHOTO-ELECTRIC CELLS

Control of power by photo-electric cells has reached a point of industrial practicability. The possibilities in controlling huge amounts of electric power by minute variations in the light falling upon a sensitive photo-electric relay are too vast to be readily imagined. The amplification constant of a single cell is approximately 100,000,000, which is several thousand fold higher than that of any other device yet invented for controlling power. Devices of this character have contributed largely to the long-distance transmission of photographs, much as the use of permalloy has made trans-Atlantic telephony possible.

PROHIBITION

Prohibition, in its various aspects, continues to occupy a central position in political chemical activities. The resignation of Brigadier-General Lincoln C. Andrews, as Assistant Secretary of the Treasury in charge of prohibition enforcement, on May 20, was followed by the appointment of Seymour Lowman, former Lieutenant-Governor of New York, to this post, and J. M. Doran, formerly chief chemist of the Bureau of Internal Revenue, was appointed Commissioner of Prohibition by Secretary Mellon. The appointment of a chemist to this important position has been widely acclaimed, except by the Anti-Saloon League. Dr. Doran's long experience in this field and his demonstrated abilities have made this choice particularly acceptable generally. The Anti-Saloon League, through Wayne B. Wheeler, actively sought the appointment of Roy A. Haynes as Commissioner of Prohibition. Whole-hearted support from industry and from other sources has been given the new personnel in this important work.

Denatured Alcohol: A strenuous campaign was carried on at the beginning of the year against the use of poisons as denaturants because of reports from many sources of the large number of

deaths caused by drinking beverages made from alcohol illegally and improperly recovered from denatured alcohol. A report made by the New York City Department of Health stated that there were 400 deaths in that city alone from the drinking of poisonous alcohol during 1926. This report was vigorously used in the campaign against poisonous denaturants, but the present impossibility of finding a suitable substitute for unrefined methanol prevented action. Although many researches have been conducted by the Bureau of Internal Revenue, no satisfactory denaturants, other than those used, have been found. Government authorities take the attitude that the burden of proof rests upon those desiring non-poisonous substitutes to produce them. This attitude was clearly stated as being opposed to any drastic changes in the present denatured alcohol act, except in the direction of making denaturants more difficult to remove.

GENEVA PROTOCOL

An attempt to pass a measure in the Senate ratifying the Geneva Protocol, which bans the use of chemical-warfare methods, was defeated by prompt action in which the American Chemical Society took a prominent part. The measure was referred to the Senate Committee on Foreign Relations, and did not come out during the last session of Congress. The belief was generally expressed that this measure would have been quickly and completely defeated if it had been allowed to come to a vote on the floor of the Senate at that time. The present status of the matter will allow it to be reported out by the committee at any favorable moment, and continued vigilance necessary to prevent its hasty passage without careful consideration of the facts.

CHEMICAL FOUNDATION DECISION

The final decision by the United States Supreme Court in the case of the United States against the Chemical Foundation, Inc., was handed down in favor of the latter on October 11, 1926. This final decision prevents further question of the validity of the trust formed by President Wilson's order to hold the

alien-owned patents seized during the war. The faith of chemists in the cause of the Chemical Foundation was not shaken during the years of litigation, but final vindication by the highest court in the country was gladly received.

PATENT DECISIONS

Among the patent decisions of importance may be mentioned that pertaining to ductile tungsten, in which the famous Coolidge patents were declared invalid; the rubber accelerator case, in which the decision was against the plaintiff—the Grasselli Company; the final decision of the Privy Council in London confirming the Canadian Supreme Court that Borrowman is entitled to priority in the broad use of greensand for water-softening; and the decree in favor of the Bakelite Corporation against the Brunswick-Balke-Callender Company. Of special interest is the decision in favor of the United States Government in its action against H. W. Houghton, wherein the invention and the patent application covering it are declared to be the property of the United States. The invention was the use of cyanogen chloride as a fumigant, and the special bearing of the decision is upon the rights of government chemists to patents taken out in the course of their employment. An appeal has been taken by the defendant.

GERMAN AND BRITISH CHEMICAL COMBINE

Efforts in Britain to form a liaison between German and British chemical interests are being vigorously opposed by the British stockholders in the firms carrying on negotiations. It is impossible to state whether this combination will be effected, but certainly there is determined opposition to it on the part of patriotic Englishmen.

GENEVA CONFERENCE

An event of international importance was the Economic Conference at Geneva, in May, 1927, under the auspices of the League of Nations. Although not a member of the League, the United States was nevertheless represented in the discussion by a group of specialists, which, however, did not include one from the chemical industry.

EVOLUTION

The Arkansas legislature recently passed a law prohibiting the teaching of evolution in its tax-supported schools. New Hampshire legislators voted down a similar measure. It is perhaps fortunate for teachers of chemistry that lawmakers are still ignorant of the periodic law.—*D. H. Killeffer, Asso. Ed. Industrial and Engineering Chemistry.*

ALPHABET

This is the only word of more than one syllable compounded solely of the names of letters. The Greek *alpha* (a) *beta* (b); our A B C book, etc.

The number of letters in an alphabet varies in different languages. Thus there are

- 21 letters in the Italian alphabet
- 22 letters in the Hebrew and Syriac alphabet
- 23 letters in the Latin alphabet
- 24 letters in the Greek alphabet
- 25 letters in the French alphabet
- 26 letters in the English, German, Dutch alphabet

- 27 letters in the Spanish alphabet
- 28 letters in the Arabic alphabet
- 32 letters in the Coptic alphabet
- 36 letters in the Russian alphabet
- 38 letters in the Armenian alphabet
- 39 letters in the Georgian alphabet
- 40 letters in the Slavonic alphabet
- 45 letters in the Persian (Zend) alphabet

49 letters in the Sanskrit alphabet

The Chinese have no alphabet, but about 20,000 syllable characters. The Japanese have seventy-two syllabic sounds, with forty-eight characters to express them.

CHEMISTRY OF STEEL CASTINGS

Among progressive foundrymen it is a well-recognized fact that the modern steel foundry is not complete without an up-to-date chemical laboratory. Many of these same foundrymen can recall the time when the chief value of a chemical laboratory was gauged not by its aid in the production of high-grade metal, but as a justification for publicity.

It is probable that the old-time chemist was mainly responsible for this attitude of the shop men. As a rule he was a young and inexperienced college graduate with theoretical knowledge only. Due to his lack of practical training, he was naturally placed at a great disadvantage in his relations with the men in the shop, and spent practically his entire time in the laboratory instead of getting out into the foundry and familiarizing himself with routine operations. Today we find in charge of steel foundry laboratory work a wide-awake man with technical ability and practical training.

When we consider that the basic operation in any steel foundry—metal manufacture—is one of controlled chemical reactions, the function of the chemical laboratory is apparent.

PRINCIPLES OF FERROUS METALLURGY

Iron in its natural state is in the form of iron ore or oxide of iron, and before it can be used, must be changed to a metallic form. This is accomplished by freeing the iron from oxygen and numerous mineral impurities by means of reduction in a blast furnace, in contact with carbonaceous matter and limestone. Heat causes the necessary reactions to take place. All chemical reactions either absorb or give off heat. Reactions required in iron and steel metallurgy are those which absorb heat, and artificial heat must therefore be supplied from an outside source.

It is not our intention to describe the operation of a blast furnace, but we have mentioned it to illustrate the fact that from the initial step to the final operation, the manufacture of iron and steel is applied chemistry at high temperature.

The point might be raised that in ancient times people succeeded in reducing iron and other ores to their metallic forms without applying any knowledge of chemistry; that they had learned from experience that certain procedures brought certain results; and that knowledge of the reactions that take place is not essential. It may be readily admitted that chemical reactions under certain conditions will take place, whether we understand them or not, but at the same time a knowledge of such reactions enables us to accelerate, retard, or limit them, resulting in a product of uniformly high grade.

Steel is an alloy of iron and carbon, the carbon being in a combined form as distinguished from the graphitic form found in cast and malleable iron. Steel also contains an appreciable amount of manganese and some silicon. Its physical values are to a great extent controlled by the percentages of these three elements.

Generally speaking, carbon adds tensile strength and hardness to steel; manganese adds tensile strength, toughness, and a lesser degree of hardness; and silicon, while it will slightly harden steel, is used chiefly as a deoxidizer or degasifier of the molten metal.

By careful control of these three elements, with relation to each other and to the other components of the metal, the skilled metallurgist can produce steel that will meet ordinary service requirements. When unusual demands are encountered which cannot be satisfactorily met by plain carbon steel, there are a variety of alloys which may be employed to give the steel the particular qualities desired.

Most of the steel manufactured today is made either by the open hearth or by the electric furnace process. These two processes are similar, except in the method of furnishing heat. In the open-hearth furnace heat is supplied by burning gas, tar, or oil, while in the electric furnace of the type most commonly used, heat is supplied through the medium of an electric arc. The electric furnace, because it generates heat elec-

trically, is not oxidizing, and does not carry to the metal products of combustion. Otherwise the chemical reactions that take place in the electric furnace are similar to those that occur in the open-hearth furnace, except for their greater rapidity, due probably to the higher temperatures employed.

The above distinction applies only to the medium used for metal manufacture. Steel-making is divided into two separate chemical processes—acid and basic. Open-hearth furnaces, as well as electric

the charge in the furnace has become liquid; portions of sand become detached from the furnace bottom, float to the top of the metal, and fuse. This liquid sand forms the initial slag in the acid process. Being of a highly acid nature, it is attracted by basic materials, since the natural tendency is to neutralize. This attraction of opposites is the secret of slag reactions in metallurgical operations.

While being melted down, steel absorbs a certain amount of oxygen and



A TYPICAL INDUSTRIAL CHEMICAL LABORATORY

furnaces, are therefore either acid or basic. A basic furnace has a bottom made of basic material such as calcium or magnesium compounds. In an acid furnace the bottom is composed of silica sand, an acid material.

Differing chemical reactions take place during the melting and working of a heat in an acid furnace as compared with a basic furnace. A knowledge of these reactions is essential to the selection of the process best suited to the manufacture of a particular product.

The acid process is necessarily of a melting and deoxidizing nature. When

other gases. The presence of these gases in the finished product is a serious detriment to the quality of the metal, and they must therefore, so far as possible, be eliminated. A large amount of gas is liberated by the simple process of boiling the metal. The appearance of the bath in the furnace during this stage of the operation is very similar to that of water boiling in an open container. Bubbles can be seen forming on top and bursting, releasing the contained gases. However, all undesirable gases cannot be disposed of in this manner. Oxygen is probably the most active ele-

ment, and if given an opportunity, will unite with almost any other element and form a compound. However, it will more readily unite with some elements than with others. This chemical law of preferential affinities is true of all elements, any one of which, when placed in contact with two or more other elements for which it has attraction in varying degrees, will always unite with that one for which it has the greatest affinity exclusively until the combining function of that particular element is completed, when it will proceed to unite with the next one in attraction. Knowledge of this law of chemistry is invaluable to the metallurgical chemist.

If the oxygen in the bath is not neutralized it will attack the iron in the metal, forming iron oxide in such quantities that it cannot be sufficiently eliminated to prevent injurious effects on the steel.

Carbon, manganese and silicon are elements for which oxygen has a greater affinity than it has for iron. For this reason the chemist provides a sufficient quantity of these elements to satisfy the amount of oxygen in the bath, and so divert its activities from the iron. Even with the use of carbon, manganese and silicon it is impossible to prevent some of the oxygen from combining with iron, but the amount of iron oxide formed is very much less than it would be if no other elements were introduced into the bath.

In making steel by the acid process, the oxygen first unites with the silicon in the charge, forming silica, which rises to the surface of the liquid metal and becomes a part of the slag. Next to unite with oxygen is manganese, forming manganese oxide, which also unites with the slag. The oxygen will now unite with carbon, forming carbon monoxide or carbon dioxide, both of which are gases and which, by force of gravity, rise to the surface of the bath and pass off into the atmosphere. Oxygen disposed of in this manner is not all present as free oxygen, the greater amount being in the form of iron oxide introduced into the original charge as rust, and as iron oxide formed while melting down with the metal exposed to atmospheric conditions. The greater

affinity of carbon, manganese and silicon for oxygen will rob the iron oxide of its oxygen and reduce the iron to its metallic form.

Having disposed of the gas formed by carbon and oxygen, and the sand produced by silicon and oxygen in the manner outlined above, there still remain in the bath, manganese oxide which was formed by manganese and oxygen, and that iron oxide which was not reduced.

The sand, or silica slag, is an important factor in the elimination of manganese and iron oxides. Being of an acid nature, it is attracted by the basic qualities of the iron oxide and manganese oxide. The fact that the entire bath when in a liquid condition is in motion, bringing the metal and the slag into close contact, affords an ideal condition for these basic oxides to unite with the slag in the effort to neutralize. The result is a constant battle between the slag and the metal. Additional silica can be obtained by the slag only as it takes it from the lining of the furnace, or from sand added by the furnace operator. The condition of the slag must be watched very closely and kept on the acid side through the addition of sand if necessary, in order to make the slag accomplish its purpose—that of removing the basic oxides from the metal.

FUNCTIONS OF CHEMICAL LABORATORY

The reactions that occur in steel-making are quite well understood at this time, and the average steel foundry laboratory is not very much concerned in experimental investigations concerning the theories of such reactions. The primary function of the laboratory is to assist in the intelligent control of these reactions.

One of the most important duties of the metallurgical chemist is to draft purchase-specifications for the raw materials required and to sample and analyze such materials. All materials that meet the specifications should be carefully stored and complete laboratory data as to composition should always be available.

Some of the raw materials that should be purchased under specifications, and

used according to information provided by the laboratory, are steel scrap, pig iron, ferro-alloys, iron ore, fuel, and bottom materials.

In acid practice no phosphorus or sulphur can be removed from the steel during the manufacturing process. Therefore the percentage of these two elements in the scrap and pig iron should be such that the average contents of the charge will be within the limits prescribed for the finished product.

It is important to know the percentage of carbon in the scrap in order to calculate a charge that will melt down with a residual carbon content satisfactory for proper manipulation of the heat. Knowledge of the manganese and silicon contents is also important in figuring a properly balanced charge. Equally important is the analysis of each material containing an alloying element so that its percentage in the finished steel may be correctly predetermined.

In fuel-fired furnaces the metal is often contaminated by the products of combustion. Oil or gas with a high sulphur content used in acid open-hearth practice raises the sulphur content of the metal in the bath.

In basic practice the bottom and slag-forming materials are compounds mainly consisting of lime and magnesia. It is advisable that these materials, generally limestone, dolomite, magnesite, and fluor-spar be purchased under very stringent specifications as to chemical composition, not only because of their influence on the product but to make sure the proper value is received for the purchase price.

It is frequently necessary for the furnace operator to know the chemical content of the metal at various stages. The laboratory is of inestimable value in rapidly making preliminary chemical analyses during the working of the heat. Speed in making such determinations is necessary if any benefit is to be gained from them. Extreme accuracy of re-

sults must be sacrificed for speed and reasonably close results.

The last function of the steel foundry laboratory in aiding control is through the final analysis of the steel as poured into molds, as soon as possible after tapping. In analyzing common steel, ordinarily the determinations are limited to those for carbon, manganese, silicon, phosphorus and sulphur. The percentages of special alloying elements if used are accurately determined. Final analyses are not made with the speed characterizing preliminary analyses. The determinations on the finished product indicate the skill of the furnace operator in producing metal meeting prescribed characteristics. If results are outside desired limits the operator's errors in making deductions regarding the behavior of the heat, or in his calculations of anticipated reactions may be ascertained.

A steel foundry laboratory performs a valuable function in making analyses of many materials used in the plant such as molding and core sands, sand binders, fuels, lubricants, welding and gas-cutting materials, bearing metals, tool steels, etc. Many of the supplies required for the manufacture of steel castings may be purchased advantageously according to specifications requiring chemical analyses to determine suitability.

It will be seen that chemistry practically applied is an indispensable factor in the operation of the modern steel foundry. It has been an essential element in the advancement of the entire foundry industry as in many others. The nature of operations in steel foundries is such as to necessitate much greater dependence on chemical science than is required for the production of other foundry metals. Tribute should be paid to the many men who, in satisfactorily but unostentatiously performing the duties of the steel foundry chemist, have contributed greatly to the present satisfactory production of high grade steel castings.—*Electric Steel Founders "Research Group News."*

HUMAN CHEMISTRY

The human body is a laboratory in which more marvelous chemical work is being done than in the laboratory of the most famous chemist alive today, said Dr. Carl P. Sherwin, Professor of Physiological Chemistry, Fordham University, in a lecture on "The Chemistry of the Human Body." In this laboratory—the human body—we find the reign of democracy to such an extent that many of us may resent it most violently. For not only are there few differences between the various chemical reactions which go on in the body of a genius and in the body of an imbecile, in the body of a European and in the body of an African savage, but the differences are no greater when we compare what takes place in the body of man and in that of the lowest animal.

Life is forever "on the go." The plant takes the carbon dioxide from the air we breathe, and with the help of simple mineral salts in the soil, with the help of leaf-green and the rays sent to us by the sun, fats and carbohydrates are built. We eat the plant, or we eat the animal which has fed on the plant; we simplify these complex fats, proteins and carbohydrates in our digestive tube—in our mouth, stomach and intestine; and then we absorb such simplified materials, use what we need of them to build and repair tissue, use some to "burn" and to get energy, and eliminate others if useless to us. As a result of the material we burn, we eliminate, among other things, carbon dioxide and moisture, which, as we have already seen, becomes the starting point for the work of the plant. And so this life-cycle continues, forever building, forever tearing down, and forever building up again.

The process of digestion takes place within a long tube, known as the alimentary canal. The mouth is the beginning of this tube, and digestion starts the moment saliva comes in contact with the food. Salivary digestion affects chiefly the starches, breaking them down first into dextrins, and then into sugar called maltose. It is possible, the speaker remarked, to reproduce this process in a glass container. By mixing saliva with some boiled starch or bread crumbs and keeping the substances used at body temperatures, it is easy through the aid of chemical tests to show exactly what happens in the alimentary canal. The experimenter observes that starch soon disappears from the digesting mixture, dextrin gradually fades as indicated by its failure to respond to the iodine test, and only sugar remains. Saliva is therefore able at body temperature to accomplish a reaction which would otherwise require the action of a boiling solution of fairly concentrated acid.

Perhaps few of us have ever stopped to consider the mass of chemical and physical changes taking place during twenty-four hours in this wonderful process which we call "Living." We are all aware that during the process, food taken into the body is digested, absorbed and transformed into living stuff; and waste products must be eliminated as rapidly as possible. By the term food we usually mean substances which are able, when taken into the body, to furnish heat or other energy, or to furnish material that living matter can utilize in growth, and that can also be used for the repair of tissues broken down during the wear and tear of everyday life.

ELECTRICITY IN 1926

TURBINES

There was a remarkable increase during the year in the unit capacity of turbine-generator sets completed and under construction.

The turbine industry is generally considered to have started with the installation of a 5,000-kw. unit in Chicago in 1903. This was followed by one of 8,000-kw. in 1906, 14,000-kw. in 1908, 20,000-kw. in 1911, 35,000-kw. in 1915, 45,000-kw. in 1917, 60,000-kw. in 1924, and 77,000-kw. capacity in 1926.

Units now in process of manufacture will extend this record with the installation of a 91,500-kw. unit in 1927, a 94,000-kw. unit in 1928, and a 208,000-kw. unit in 1929.

The fact that these last three units are being constructed for dates of installation so far in the future is an impressive illustration of the foresight necessary today in the central station industry.

The 208,000-kw. set will be installed in the State Line Station of the State Line Generating Company near Hammond, Ind. This three-unit set will operate under steam conditions of 600-pound pressure and 750 degrees, Fahrenheit, steam temperature at the throttle. Reheating will be accomplished between cylinders.

During the year two important stations were placed in successful commercial service. They are the Columbia Park Station of the Columbia Gas and Electric Company and the Richmond Station of the Philadelphia Electric Company.

In the former, two 45,000-kw. tandem-compound units with single flow in the low-pressure end are installed. These machines operate with steam pressure of 550 to 600 pounds. The steam is reheated between cylinders to its original temperature of 725 degrees, Fahrenheit.

The machines in the Richmond Station are of 60,000-kw. capacity and are also tandem-compound units but with double flow in the low-pressure cylinder.

The steam conditions are 375 pounds at the throttle with a temperature of 675 degrees, Fahrenheit. They also operate on the regenerative cycle.

During the year there were in successful operation seven turbine-generator sets of 40,000 to 60,000-kw. capacity under steam conditions of 550 to 600 pounds, 700 to 725 degrees, Fahrenheit, steam temperature, with reheating after partial expansion.

The 77,000-kw. cross-compound turbine-generator set built for the Crawford Avenue Station of the Commonwealth Edison Company of Chicago is now in successful operation and a 90,000-kw. unit of the same general design for this station is now under construction.

Other large sets completed include a 60,000-kw. single-cylinder 25-cycle turbine-generator for the Buffalo General Electric Company and two 60,000-kw. single-cylinder 25-cycle units for the East River Station of the New York Edison Company.

Two 52,500-kw. tandem-compound machines for the Societe Financiere de Transports for installation in Buenos Aires are designed for 550-pound steam pressure and will operate on the reheating, regenerative cycle. This is the first development of this kind outside of the United States.

The fifth station in this country to use 550 to 660-pound steam pressure is now in service. It is the Stanton Station, owned jointly by the American Gas and Electric Company and the Electric Bond and Share Company. The initial installation consists of two single-casing units designed for operation on both the reheating and regenerative cycles. Each turbine drives a 40,000-kw. main generator and a 2,000-kw. auxiliary generator.

A 52,800-kw. single-cylinder 1,500-r.p.m. unit built for the Southern California Edison Company is now in service, and two 94,000-kw. 1,500-r.p.m. tandem-compound units, each consisting of a 90,000-kw. 100,000-kv-a. 16,500-volt

main generator and a 4,000-kw. auxiliary generator, are in process of construction.

The main generators of these latter turbines exceed in both capacity and physical dimensions any electric generator previously built and the turbines are also the largest of the tandem-compound type so far constructed. Each turbine-generator will measure 103 feet in length and weigh about 1,650,000 pounds.

The Edison Electric Illuminating Company of Boston will utilize a 65,000-kw.

1,200-r.p.m. units for the Detroit Edison Company are being built.

After a year's operating experience with the 1,200-lb. pressure turbine in the Edgar Station, the Boston Edison Company states that "This high-pressure installation is not a full or complete development of the high-pressure possibilities in the Edgar Station and it is expected that a full development of this equipment will bring the generating records of the station down to a kilowatt-hour for nine-tenths of a pound of



GENERATOR SHELL ON ARC WELDER

turbine-generator unit, which will operate at 1,800 r.p.m. and consist of a single-cylinder turbine driving a 60,000-kw. 75,000-kv-a. main generator and a 5,000-kw. 6,250-kv-a. service generator. It will be placed in the Edgar Station at Weymouth.

The first 50,000-kw. 1,800-r.p.m. single-cylinder single-flow turbine-generator set is practically completed and will be installed in the Cahokia Station of the Union Gas and Electric Company of St. Louis, and two additional 50,000-kw.

coal." No difficulties attributable to the high pressure have been encountered. It is no more difficult to operate such a machine than one for standard pressure and it seems entirely feasible to develop much larger units.

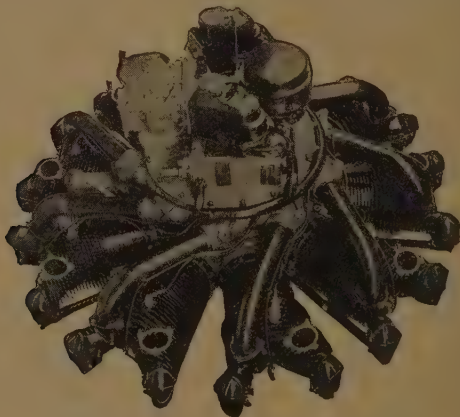
A 7,000-kw. machine designed for the same initial conditions but for somewhat lower back pressure for the Milwaukee Railway and Light Company is also operating commercially.

From a generator standpoint, the most important installation made during the

year was that of two 62,500-kv-a. 1,800-r.p.m. generators in the Richmond Station of the Philadelphia Electric Company. These machines are not only the largest turbine-generators at this speed that have been built, but they have incorporated in them the developments in generator design and construction which have resulted from research and tests for the past two or three years and which have combined to make them the most efficient turbine-generators in operation. The net result of such features was an efficiency of 98 percent, by test in the Richmond Station.

Preliminary tests during the latter part of 1925 and early 1926 showed the necessity for making several minor changes and repairs to the mercury boiler. These were made and by the end of April, 1926, the boiler was again ready for operation. From then to the end of August the equipment carried commercial load during the day, being shut down at night and over week-ends.

It is expected that a large commercial mercury unit will be constructed for installation at the South Meadow Station of the Hartford Electric Light Company. It is estimated that it will con-



SUPERCHARGER ON AVIATION ENGINE

Stainless steel is now utilized for all buckets except those in contact with very high temperature steam and those long buckets in the last few stages in the exhaust end of large machines. Steam, mechanical and electrical research were diligently continued in order to build an ample foundation for the future requirements of the industry.

EMMET MERCURY VAPOR PROCESS

During the summer of 1925 a new type of mercury boiler and a new three-stage mercury turbine were installed at the Dutch Point Station of the Hartford Electric Light Company, replacing the fire-tube type of boiler and single-stage turbine installed in 1923.

sume 14,400 pounds of coal per hour and will deliver 10,000 kw. from the mercury generating unit. In addition, the condensing mercury will generate 124,000 pounds of steam per hour which will be superheated to 750 degrees, Fahrenheit.

INDUSTRIAL TURBINES

In addition to the advances made in the large turbine-generator sets for central station service, numerous improvements of great practical value were secured in the design of the relatively smaller sets utilized in industrial plants. The use of process steam as a by-product of electrical service was a conspicuous feature of several exceptional installations of this class.

The Raritan Copper Works at Perth Amboy, N. J., is devoted to the electrolytic refining of copper and utilizes a considerable amount of process steam at different pressures. In order to meet an increased demand for both power and process steam, two 5,000-kv-a. and one 3,125-kv-a. automatic extraction turbine-generators were installed. These three units operate at 3,600 r.p.m. and were designed to receive steam at 365 pounds gauge pressure and 200 degrees, Fahrenheit, superheat at their throttles. The prime movers, previously installed, utilized steam at 165 pounds gauge pressure.

The Viscose Company, manufacturers of Rayon (artificial silk), require electrical power of both 60 and 100 cycles, the latter for the operation of small high-speed motors. Much process steam at low pressure is also needed. To meet these conditions, four special turbine-generators were installed.

SUPERCHARGER

The centrifugal type of supercharger, which was originally developed for use in connection with airplane engines for high-altitude flying, was embodied in a modified form intended for relatively low-altitude flight in a new type of air-cooled radial aviation engine.

The supercharger, or rotary induction system, as it is now commonly known, is located between the carburetor and the intake manifold. In its latest form, it is built directly into the engine crank case and does not materially affect either the size or the weight of the engine.

Its function is to draw gasoline and air through the carburetor and compress it sufficiently to overcome the normal pressure drop through the carburetor. This means that the mixture is delivered to the engine intake manifold at or slightly above atmospheric pressure. Engines of this class rated as high as 500 h.p. have been so equipped.

MARINE EQUIPMENT

As a result of the successful operation of a 13,000-ton self-unloader type of bulk freighter equipped with turbine-electric drive and electrical unloading equipment, which was put into service

in July, 1925, a still larger ship of this class is now under construction.

It will be the largest bulk freighter on the Great Lakes, with an over-all length of 637 feet and a beam of 65 feet, and its entire equipment will carry out the most advanced engineering practice both in regard to the steam conditions and to the completeness of the electrification of its auxiliaries.

The turbines will be supplied at 300-pound pressure and a total temperature of 700 degrees, Fahrenheit, and will operate on a vacuum of 28½ inches. These steam conditions represent a distinct advance both in regard to pressure and temperature for ships of this class.

The power developed will be normally about 4,200 s.h.p., but the equipment is capable of giving a maximum continuous output of 4,800 s.h.p.

Diesel-electric propelling equipment is under construction for three tankers of 7,000 dead-weight tons each. These are single-screw ships and the generating equipment for each consists of three 525-kw. 250-volt direct-current machines driven by three 850-b.h.p. engines, each generating unit being provided with a 50-kw. direct-connected auxiliary generator. The three main generators are normally operated in series and supply current to an 1800-s.h.p. 90-r.p.m. 750-volt shunt-wound propelling motor.

These ships were purchased from the United States Shipping Board by the Atlantic Refining Company, and were originally steam operated, but experience with similar craft provided with Diesel-electric drive resulted in the adoption of this method of propulsion.

The control will be arranged for operation either from the pilot house or the engine room. All the auxiliaries will be electrically operated and will receive their current supply normally from the 50-kw. auxiliary generators, but a 35-kw. standby Diesel-engine-driven generator will be available for emergency and port service.

The first Diesel-electric dredge on the Great Lakes, the *Sandmaster*, was placed in service in May and is the most advanced vessel of her type in the world today.

Like the tankers just referred to, the *Sandmaster* was originally a United

States Shipping Board craft and operated by steam, but her conversion to Diesel-electric drive permitted not only more economical operation of the propelling machinery but also rendered possible the most flexible arrangement and control of the large pumps and other auxiliaries required for the operation of a suction dredge.

With an over-all length of 263 feet and a beam of 43½ feet, the main machinery consists of two 600-h.p. engines

per hour through a maximum pipe-line length of 8,000 feet, and can build up a hill of sand 90 feet high at that distance from the source of supply.

The auxiliaries, which are all electrically operated, include the steering gear, anchor and mooring windlasses, etc., in addition to the main pumping units.

A new 15-inch hydraulic dredge for the United States Navy utilizes 3-phase 60-cycle alternating-current motors. The



ELECTRICALLY OPERATED UNLOADER

with 400-kw. 240-volt direct-connected generators which supply current to two 500-h.p. 130-r.p.m. motors that are direct-connected to the twin screws. Each of these driving motors can be controlled independently from either the pilot house or the engine room.

The two main sand pumps are each electrically driven by a 400-h.p. 450-r.p.m. motor and the two jetting pumps by 125 h.p. 1,700-r.p.m. motors. Some idea of the effectiveness of this dredge can be gained from the fact that it is capable of handling 3,000 tons of sand

main dredge is equipped with a 600-h.p. 165/265-r.p.m. motor, and the cutter with a 75-h.p. 300/600-r.p.m. motor. The main dredge motor operates at 2,200 volts, but 220-volt service is provided for the auxiliary equipment.

The most powerful dipper-dredge ever constructed, the *Crest*, was placed in service and is now being used in rock removal work in New York Harbor. The primary power consists of two 600-h.p. Diesel-engine-driven generators and more than 1,400 h.p. in motors is required for the dredging operations. At

present, 10-cubic yard dippers are being used on account of the severity of the work, but in normal service buckets up to 15 cubic yards can be utilized. The pull on the dipper bail is 350,000 pounds, or nearly half again as much as that of the largest size dredges used in the construction of the Panama Canal.

Propelling equipments for four Diesel-electric ferries represented a greater power for this type of craft than has heretofore been used.

These ferries are under construction for the Southern Pacific R.R. Company and each of these double ended boats will be equipped with four 275-kw. direct-current generators individually driven by four 450-h.p. engines, the two propellers being each driven by a 1,250-h.p. 1,000-volt double-armature direct-connected motor.

The type of automatic mooring winch which was originally designed for marine service was successfully applied for mooring an airship to the Ford airmast at Detroit, and its satisfactory operation has resulted in the decision to equip the Scott Field mooring mast near St. Louis with a similar machine.

An electric automatic towing machine was installed on the tug *William A. Lydon* operating on the Great Lakes.

The electrical equipment comprises a 50-h.p. motor, a contractor panel, and two master switches: one an automatic switch operated from the tension-responsive device in the mechanical gearing, and the other a manual switch.

ELECTRIC RAILWAYS

Requirements for new car equipment for the electric railways of the country indicated a marked improvement in this branch of the industry. In practically every case, the new equipment now being placed in service is of the light-weight type, taking advantage of improvements in manufacturing methods and of the reduced operating costs thereby secured. For both city and suburban service four-motor light-weight cars are being equipped, as the service conditions require, with either 25- or 35-h.p. motors and platform-type control.

Evidence of continued activity in the electric railway field was indicated by

the country-wide distribution of the various rehabilitation programs undertaken.

The first road to adopt the standard A.E.R.A. light-weight car was the Berkshire Street Railway, Pittsfield (Mass.), which has under construction 12 new cars built to these standard specifications with an equipment of four 35-h.p. motors, air brakes, headlights, compressor and platform-type control.

After a thorough try-out of the three-car articulated units designed for heavy subway and elevated service, the Brooklyn-Manhattan Transit Corporation installed 67 of these units provided with 134 air controls, two on each three-car unit, and 268 200-h.p. motors.

Each of these units is 137 feet long and consists of three car bodies mounted on four trucks. Each three-section unit will seat 160 passengers. With a four-unit train of these cars, as many as 2,000 passengers can be handled at one load.

Renewed activity in railroad electrification was shown in the United States by new work and extensions by several companies. One of the most important of these is the Great Northern Railway which is pushing forward an electrification project covering a distance of eighty miles from Skykomish (Wash.) to Wenatchee. By the time this division is ready for electrical operation, the new $7\frac{3}{4}$ -mile tunnel under the Cascade Mountains will be completed and the present three-phase electrification through the Cascade tunnel discontinued.

Two locomotives are being built for this project; the total weight being 250 tons each with 200 tons on the driving wheels. Power is received through a pantograph from an 11,000-volt single-phase 25-cycle supply and transformed to direct current through a three-unit motor-generator set having a nominal rating of 2,500 kw. There are six driving motors each connected to an axle through twin cushion-type gears. Regenerative electric braking will be used for the first time on this type of locomotive.

A very interesting electrification project is being put through by the Anglo-Chilean Consolidated Nitrate Corporation, at Tocopilla (Chile). The present

section of steam road being changed over is 40 km. in length and passes through an exceedingly dry desert country. There are now under construction for this project five 66-ton locomotives. Power will be supplied at 1,500 volts direct current from two 1,500-kw. substations and provision has been made for regenerative electric braking on the down grades. The maximum grades are 4 percent and the track gauge is 42 inches. The principal traffic is hauling nitrate from concentration plants to the port of Tocopilla.

The fact that it never rains in this part of the country and that all water has to be transported for some distance, or distilled from sea water, gives the electric locomotive a considerable advantage over steam engines.

Power is transmitted from an oil-engine station a distance of about 40 km. in addition to the line paralleling the electrified tracks. The transmission line potential is 33,000 volts, 60 cycle, 3 phase.

The electrification of the Illinois Central suburban lines south of Chicago was completed in July, 1926, and the operation of the equipment has been reported entirely satisfactory. On this road, for the first time in this country, power was supplied by mercury arc rectifiers.

The suburban business of this railroad constitutes about one-third of all the suburban passenger traffic in Chicago. At the present time, about 87,000 suburban passengers are handled every week-day on 418 trains and it is predicted that this traffic will increase to more than 100,000 passengers daily in the near future.

Extensions of the present electric zone of the New York Central Railroad around New York City and increasing traffic required additional equipment for this Company. During the year a new electrified section was opened on the Putnam Division between High Bridge and Yonkers using multiple-unit cars which are duplicates of those operating on the present terminal division. Ten car equipments, consisting of 200-h.p. motors and pneumatic-type controls, duplicates of those previously

used, were placed in service. For supplementing the motive power for passenger work, ten 130-ton gearless locomotives, similar to those which have been in service since 1916, were placed in operation the latter part of the year. Freight and switching locomotives which were under construction, in preparation for the electrification of the West Side tracks, were also placed in service. These include two freight locomotives weighing 170 tons each and seven switching units weighing 100 tons each.

In connection with the electrification of its lines between Philadelphia and Wilmington, the Pennsylvania Railroad is securing motor and control equipment for four 200-ton locomotives and for thirty single-phase multiple-unit cars. The locomotives are being built by the railroad company.

The motors are designed to operate either on alternating or direct current, but for the present the locomotives will be used in passenger service on the 600-volt direct-current terminal division between New York and Manhattan Transfer. Each locomotive will be equipped with four motors, two being geared to a jack shaft and side rods at each end of the unit.

Increasing business on the New York, New Haven and Hartford Railroad, particularly in the electric zone, necessitated new equipment, a part of which was under construction a year ago. The locomotives placed in service are of the motor-generator type taking power from the 11,000-volt trolley and transforming it to direct current, which is utilized in standard railway-type motors. Five of these freight locomotives, weighing 140 tons each, and two switching locomotives of a similar design, weighing 100 tons each, are now in operation.

Experience with the oil-electric locomotive, several of which were placed in service in 1925, was uniformly successful as is indicated by the fact that there are now in service eleven 60-ton units and three 100-ton units. While most of these are assigned to railway work, one of the 60-ton units is being used by the Inland Steel Company in industrial work and a 100-ton unit is making a very successful record in the lumber industry.

The first of this type of locomotive to be used for road service will be those now under construction for the New York Central Railroad (Putnam Division). One of these is equipped with a 750-h.p. Ingersoll-Rand oil engine for freight service and another with an 880-h.p. McIntosh and Seymour engine for passenger service. A third unit for this same Company, weighing about 120 tons, is being equipped with a 600-h.p. Nelseco engine, and a fourth unit also weighing about 120 tons will be a combination oil-electric storage-battery third-rail locomotive having a 300-h.p. Ingersoll-Rand oil engine and a powerful storage battery. These last two units

While most of these cars use a single engine and generator, it is possible to use two units, thus doubling the amount of power available. A car of this type is being used on the Seaboard Air Line where the power demands exceed the limitations of a single unit.

A novel application of this type of gas-electric drive is used in combination with a storage battery on a locomotive utilized for switching service in the Chicago and Northwestern Railway Company's yards. This locomotive weighs approximately 110 tons and is equipped with a storage battery of sufficient size to handle a normal switching service during the day. At night it is



100 TON DIESEL-ELECTRIC LOGGING LOCOMOTIVE

will be used in the lower West Side Yards in place of existing steam equipment.

There have now been built for the various steam railroads of the country approximately 120 gas-electric motor-car equipments with the main generator direct-connected to a six-cylinder gasoline engine, two-gear railway motors and necessary control.

An interesting feature of the gas-electric equipments for the Boston and Maine Railroad was the adaptation of the engine to the use of distillate fuel. Provision was made on these cars for starting with gasoline and then automatically switching to the cheaper fuel during the larger period of their operation. When the engine is idling, however, it reverts to the gasoline supply.

expected that it will be recharged from the power company's supply.

This unit differs from the ordinary storage-battery locomotive in that it is equipped with an auxiliary gas-electric generating set which will be used in emergency to assist in operating the locomotive or, when the locomotive is idling, to help recharge the batteries.

The use of gas-electric transmission equipment for heavy city buses met with continued favor, particularly with electric railway operators who are familiar with the reliability of the electric motor. Its popularity is attested by the fact that, where a total of about 250 equipments were in service a year ago, there are now in actual operation about 1,000 buses using this type of drive.

The Philadelphia Rural Transit Com-

pany operating in Philadelphia was the first to adopt electric drive on a large scale and now has its entire fleet so equipped. An interesting application made by this Company is the adoption of gas-electric drive for snow plows, of which fifteen will be in operation this winter. While this Company originally planned to use buses in Philadelphia only for congested traffic, the field has now been broadened to include interurban traffic to Baltimore, Washington and New York, and a fleet of touring buses to more distant points.

Another large user is the Public Service Company of New Jersey which has nearly 400 buses in service.

WATERWHEEL GENERATORS

While the development of hydro-electric systems was overshadowed by the enormous expansion which occurred in the steam-driven equipment of the public utilities, the aggregate capacity of waterwheel generators produced was greater than in 1925. At the close of the year there had been completed, or were under construction, more than 30 units rated at 10,000 kv-a. and above.

There was a notable increase in the use of the spring-type thrust bearing, especially for the larger units, and a more general adoption than heretofore of a closed system of air circulation whereby the heated air is passed through water-cooled radiators and recirculated. In many cases, steel-plate construction was utilized in both rotor and stator in order to minimize the use of the heavy castings heretofore characteristic of this type of generator.

INDUSTRIAL HEATING

A new application of the immersion type of electric heating unit consisted of utilizing it in existing standard fuel-fired types of the stereotype pots or furnaces used in printing plants.

The heating units are located on the inside of the pot and the heat is delivered to the metal for the depth of the entire charge, thereby producing heat for surface melting so that no undue strains, tending to crack the crucible, will be set up in the stereotype metal. Automatic heat control is utilized.

Pots of this type in capacities up to six tons were equipped for operating at a maximum temperature of 650 degrees, Fahrenheit, with a current consumption of 150 kilowatts.

Caustic soda fusing on a commercial scale was accomplished for the first time by electric heat. This work is done in kettles 10 feet in diameter, each holding about 30 tons of caustic. The connected load for each kettle is 500 kilowatts, and the heating units are mounted outside the kettle and are automatically controlled. Low temperatures are utilized in starting the operation and are gradually increased to a maximum of 600 degrees, Fahrenheit.

ELECTRIC REFRIGERATION

As the result of wide experience with installations of household refrigerating equipment, a number of improvements were made in the design of the self-contained refrigerating unit in order to insure greater reliability.

The refrigerating mechanism is totally enclosed and is provided with a permanent oil supply so that the entire equipment with its thermostatic control will operate continuously without attention after it is installed.

RESEARCH

The cathode-ray tube was improved to the point where it is possible to seal it off from the exhaust pump, thereby making it as thoroughly portable as an X-ray tube. Larger tubes were constructed and the maximum operating voltage was raised from 200,000 to 400,000 volts.

The electrons of the cathode-ray stream are supplied by a coiled tungsten filament, or hot cathode, heated to incandescence by a relatively low voltage. The other electrode, or anode, is the nickel "window" which is soldered to a disk of invar.

By impressing high voltage between the electrodes, electrons are driven from the hot cathode to and through the anode or window with a velocity of about 150,000 miles a second.

The window is very thin, although equivalent to the thickness of about 500,000 layers of atoms. In terms of

electrons, however, it hardly exists, since there is so much space between the electrons forming its atoms. For this reason it permits the high-speed electrons from the hot cathode to pass through it into the air. The air is barred from entering the tube because the gas molecules, enormous in size when compared with electrons, are too big to go through the spaces between the electrons in the atoms of nickel.

The window has an area of about nine square inches, and must withstand a pressure of 100 pounds from the atmosphere. It is therefore supported by a honeycomb structure of molybdenum.

Another feature of the tube is the use of a protecting shield, a copper tube extending lengthwise from near the cathode and attached to the invar disk which supports the window. This tube confines the stream of electrons and keeps them from impinging on the glass. Thus high-voltage sparks through the glass, with consequent punctures and destruction of the tube, are avoided.

Practical commercial and therapeutic applications for the new tube are yet to be developed, but during the year numerous experiments were made to ascertain its effect on a variety of gases, liquids, and solids, as well as on living tissue.

The high-speed electrons delivered by the cathode-ray tubes are similar in character to the electrons liberated by the disintegration of radium. The electrons given off by radium are of higher velocity than those so far produced by the cathode-ray tube and the rate at which they are produced by the disintegration of radium is beyond control. The rays produced by any of the recently constructed cathode tubes exceed in quantity those which could be produced by a ton of radium, and the rate of production and the depth of penetration of the tube rays are under absolute control. This characteristic is of great value in experimental work and may be of vital importance if these rays are utilized in therapeutics.

The type of mercury-arc tube with grid control, known as the "Thyratron," was produced in larger units, some of which have been operated up to 225 kilowatts at 1,500 volts.

WELDING

The experimental work on the process of welding by a flame of atomic hydrogen and the development of apparatus for its commercial application were continued.

Many different forms of welding torches were constructed and tested. The electrodes between which the arc passes are mounted at a convenient angle to one another and are adjustable so that they can be brought into contact at a point which is exposed to a blast of hydrogen from one or more orifices. Thus the atomic hydrogen is blown out of the arc in a definite direction and forms a flame which can be brought into contact with the metal to be welded. The jet of hydrogen also serves to bathe all the heated parts of the electrodes and the work, thus preventing oxidation and the introduction of impurities such as nitrogen into the weld.

Research work of a non-electric character and of great practical value to industry consisted of a series of exhaustive experiments to determine the possibility of substituting illuminating gas for the more expensive gases which have heretofore been considered necessary in the use of torches for metal cutting.

It was demonstrated that, with suitable preheating, city gas of proper quality is an ideal fuel gas for plate cutting, riser cutting in foundries, scrap work especially on thick materials, and other similar applications. Its economy is not as great when cutting rivets, or very thin plates.

When city gas is used it is safe to employ a super-heating coil in the torch for heating the cutting oxygen. The economies possible with such a device are very marked especially during cold weather, and the introduction of such a coil permits the utilization of city gas with a considerable reduction in oxygen consumption compared to present oxy-acetylene and oxy-hydrogen practice. For metal of considerable thickness, the oxygen consumption is no greater with city gas than with any other fuel gas, and by using a super-heating coil the difference favors city gas.

Suitable cutting torches were there-

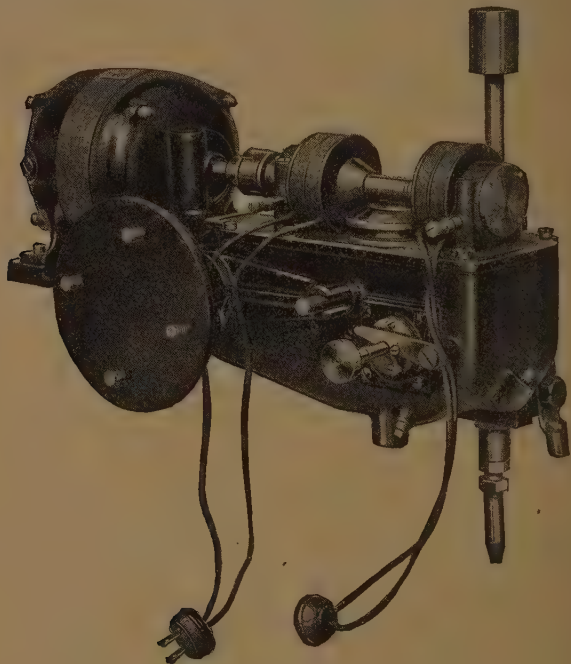
fore designed and the new method utilized commercially on an extensive scale, the operating costs showing an actual reduction of 30 to 50 percent in comparison with those of previous methods.

ELECTRIC WELDING

The use of electric arc welding as a manufacturing process was considerably

seam. In the machine for welding smaller frames, the work is rotated past the heads, which are held stationary.

In addition to the extension of applications, there were several innovations in the welding apparatus proper, especially in that used for automatic welding. Of these the most notable was the development of a new type of automatic welding head.



ELECTRODE-FEEDING MACHINE FOR WELDING

extended. Among the more interesting applications were two machines designed for the automatic welding of the circular seams in generator stator frames, one being capable of welding seams up to 28 feet in diameter, and the other for use on seams of small or medium diameter. In the case of the former, the work is held stationary, while two automatic heads are revolved about it simultaneously to weld the

The welding head, which feeds the electrode to the arc, consists essentially of a pair of feed rollers geared to a constant-speed motor through a magnetic clutch. The gearing and feed mechanism are mounted as a unit in a housing to which the motor is bolted. The speed of wire feed may be altered by means of a three-speed selective gear changer which is manually operated. This arrangement permits easy and ac-

curate adjustment of the feeding speed to suit the size of electrode wire and the welding current being used.

The control is entirely automatic and magnetic in character, incorporating all the devices necessary to start and stop the wire-feed motor, for interlocking the travel motor with the arc, and for controlling the magnetic clutch which connects the feed motor to the feed rolls. All of the necessary equipment is compactly mounted on a totally enclosed panel which can be located wherever convenient.

Several improvements were also made in the various machines used in the automatic welding of tanks, pipe, etc. One of these consists of a travel carriage with two automatic welding heads for welding heavy plate, that is, three-eighths inch or greater in thickness. By means of the new arrangement two layers of metal are deposited simultaneously in the joint or seam. Thus, not only is the strength of the finished weld increased, but its quality is improved and the over-all welding speed is increased 100 percent.

The design of the clamps used with automatic welding machines was improved by the incorporation of two new features. One of these is the magnetic control of the arc, and the other the positive pneumatic clamping of the work. The former consists of a new method for controlling the stray magnetic fields which, arising from various causes, tend to disturb the arc and thereby affect the quality of the finished weld. The improvement consists of an insulated conductor which is placed underneath the copper chill bar, or backing bar, of the machine, and through which all or part of the welding current can be shunted. By this means a magnetic field is secured of the proper magnitude and direction to insure the best operating condition for the arc.

The second improvement, a new form of pneumatic clamping, resulted in permitting the use of higher welding currents and greater welding speed.

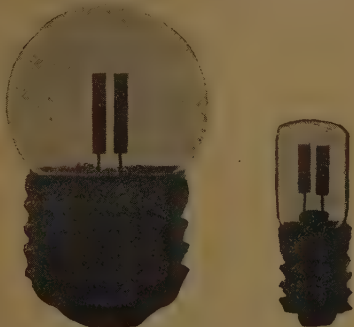
FUSED QUARTZ

In the past it has been difficult to produce fused quartz tubing of any specific bore and wall thickness unless wide

tolerances, or limits, in diameters were allowable, the amount of tolerance depending entirely on the skill of the artisan. These limitations have now been eliminated.

Large disks of quartz, suitable for reflecting telescopes, 11 inches in diameter, 2½ inches thick, were produced, as well as prisms of various sizes, the largest having faces four inches square. This is noteworthy in view of the fact that such masses of clear fused quartz have never before been available.

Three disks of clear fused quartz about 10 inches in diameter and 1½ inches thick were supplied to the Bureau of Standards of the Department of Commerce for the purpose of preparing standards of flatness. The nec-



NEW AND OLD ROUGH SERVICE LAMP
COMPARED

essary polishing work was done by the Bureau of Standards, and resulted in the production of three disks, each less than 1/100 of a light wavelength out of true planeness. Some idea of what this precision means can be obtained by assuming one of these disks to be enlarged until it reached from Washington to Chicago and then noting that no point on it would be out of plane by as much as one inch.

LIGHTING

A new 50-watt rough service lamp was produced because it was realized that the new standard 50-watt lamp would not be as satisfactory under special conditions of rough service as the

former 50-watt mill type lamp. The new lamp is inside frosted, and renders it possible to improve lighting conditions where lamps are subjected to severe shock, by replacing the antiquated carbon type of lamp.

A new lamp for street railway service was designed to permit the use of gas-filled lamps in street cars. This type has, in the past, been largely ex-

developed which consists of a bulb filled with a mixture of rare gases, two magnesium electrodes inside the bulb, and a high resistance in the base.

When alternating current of 100 volts or above is applied to the lamp, the gas is ionized, becomes conducting, and is thrown into luminous vibration around the negative electrode. The gas immediately surrounding the electrode glows



NEW GAS-FILLED RAILROAD LAMP

cluded from the field of street car lighting because of the limitation imposed by an inherent characteristic of gas-filled lamps. The limitation arises from the fact that when five such lamps are operated in series on a 600-volt circuit, the failure of one of them is liable to cause an arc to form, and be maintained across its lead wires. This arc used to work up into the base and socket, damaging the latter.

A novel type of electrode lamp was

with a soft pinkish glow, or corona. On alternating current first one electrode and then the other is negative alternately, and each in turn glows. At 60 cycles the alternations are so rapid as to cause both electrodes to appear to be continuously lighted. On direct current only one electrode glows. When operating on direct current about 40 per cent higher voltage is required.

The actual candle power of these lamps is very low, about 1/500 c.p., but

the color of the light is such that it falls in that portion of the spectrum to which the eye is quite sensitive. The lamp, therefore, makes an excellent indicator, but should not be considered as an illuminant.

Aviation Lighting

The passage by Congress and the signing by the President of the Air Com-

points, where lighting is necessary, it must be provided by the municipality or the operating company.

A new boundary marking light was produced for placing around the borders of aviation fields, consisting of a series street lighting socket and receptacle enclosed by a sheet metal case and surmounted by a glass globe. The fixture is mounted on an iron pipe about three



AN UNUSUAL ILLUMINATION

merce Act placed with the Department of Commerce the responsibility for establishing and maintaining airways for the contract air mail routes. The present mileage of the contract routes is over 5,000 in addition to 2,669 miles of Government operated transcontinental lines. Lighting will be necessary on a large amount of this mileage.

The Department's responsibility for lighting does not include the lighting of terminal fields or airports; at these

feet from the ground. When used as a boundary marker, a clear or inside frosted globe is used. For marking obstructions red globes are substituted. When it is desired to mark favorable approaches to the field for landing, green globes are installed adjacent to the ends of the runways.

The general arrangement of airports has become fairly well standardized in the United States, and a corresponding advance has been made in the illumina-

tion equipment required. This applies equally to airports for military, postal, and commercial planes. The airports are now generally equipped with boundary lights, obstruction lights, floodlights, and searchlight beacons.

Searchlights

A newly designed form of searchlight mirror resulted in an increase of 18 percent in the beam strength of the 60-inch high intensity searchlight. A mirror of the new design gave 1,035,000,000 candles in the center of the beam in place of 875,000,000 candles which is the highest intensity attained previously with the standard mirror.

This increase of intensity was secured by using parabolic curves for both the front and rear surfaces of the mirror glass, and relating the curves in such a manner as to secure a better concentration of the reflected light. Because both surfaces are parabolic, they are

readily formed by present manufacturing methods and this design of mirror is therefore well suited to supersede those of previous construction in all sizes.

Spectacular lighting effects were obtained at the opening of the Great Western Gateway Bridge, which spans the Mohawk River at Schenectady, New York. These were secured by the combination of fireworks and batteries of searchlights which were used to accentuate them. Incidentally, this bridge is perhaps the most intensively illuminated structure of its kind, being provided with an ornamental type of bronze lamp casing, supported by brackets mounted on concrete columns on both sides of the bridge, stationed 125 feet apart and opposite each other. The lights are 17 feet above the roadway, on which the light intensity is 270 lumens per linear foot.—*John Lister, General Electric Review.*

CENTER OF INDUSTRY

In January, 1908, the center of industry in the United States was on the northern boundary of Indiana, about 110 miles east of Chicago. In January, 1918, it was still on the northern boundary of Indiana but had moved about fifty miles nearer to Chicago. In January, 1926, it had moved twenty-five miles to the southwest of its position in 1918 and was about fifty miles southeast of Chicago. The total movement in the eighteen years from 1908 to 1926 was about seventy-five miles in a west by south direction. This slow movement of the center of industry during a period when the capacity of prime movers in central stations and manufacturing plants increased about 140 percent indicates that industrial development in the United States is proceeding at about the same rate in all sections but a trifle more rapidly in the western and southern parts of the country.

These determinations of the center of industry, which have been made by the Geological Survey, Department of

the Interior, are based on the capacity of steam engines, steam turbines, water wheels, and internal-combustion engines installed in manufacturing plants and in public-utility power plants. Twice the weight is given to the power equipment in public-utility power plants, as it is used twice as much as power equipment in manufacturing plants. Previous determinations of the center of industry have been based on the installed capacity of prime movers in manufacturing plants only. It is believed that more representative results are obtained by using the capacity of power equipment in both manufacturing and public-utility plants.

The geographic center of the United States is near the center of the northern boundary of Kansas, and the center of population is in Owen County, southwestern Indiana. The center of industry of the United States in 1926 was, therefore, 640 miles east by north of the geographic center and about 170 miles due north of the center of population.—*U. S. Department of Interior.*

SOIL ELECTRICALLY HEATED

EXPERIMENTS IN SWEDEN

Successful experiments with out-of-season crop production by heating soils with electricity are reported to have taken place in Sweden by Consul General at Stockholm, J. B. Osborne. In a statement just made public by the Department of Commerce, he says that recent tests with lettuce have enabled placing that product on the market out of season and reviews other past and planned experiments. The full text of the statement follows:

A number of experiments to ascertain the practicability of heating soil with electricity and thus produce crops out of season, were carried on in Sweden during 1926. On one farm near Stockholm, it is reported, the tests resulted so successfully that it was possible to raise lettuce and place it on the market in March, with future prospects of being able to modify the seasonal environment to such an extent that lettuce will be put on the December market.

The first attempt to warm soil with electricity in Sweden was made with a current of five to twenty-five volts sent through a lead wire, not insulated, which ran underneath the ground. This method was found to be impractical, however, due in part, to the high costs of operation.

The next trial was made with a specially manufactured heating cable provided with armatures of special construction. In 1926 these devices were tried in six forcing beds in a market garden near Stockholm. Results of this

attempt were quite satisfactory, it is said, and the owner of the place now has 1,300 square meters of forcing bed soil electrified in this way. Power is provided through a specially constructed transformer which reduces the current from 3,000 volts to 127. The power is then distributed through the beds where it warms the air underneath the glass as well as the soil.

In the latter part of February, 1927, eighty thousand lettuce plants were set in the forcing beds of the market garden where the electrification experiments are in progress. It was anticipated by the gardeners that this lettuce will be ready for market by the first of April, a feat which could have been accomplished heretofore only in greenhouses.

In the far north of Sweden where there is plenty of sun in certain seasons of the year but where the soil is comparatively cold, considerable interest has been shown in the possibility of electrical heating of the soil. Trial beds have been set down in three localities.

Agricultural authorities at the Stockholm Agricultural Experiment Station will attempt to electrify soil in an open field having an area of two thousand square meters, in which 110 electric wires set forty meters apart will be used. It is hoped in Sweden that potatoes may be planted in April in this field and harvested in the early part of June. What is needed, it is said, is a ground temperature to correspond to the comparatively high air temperature in the spring of the year.—*Courtesy of U. S. Daily.*

AIR-COOLED AVIATION ENGINES

AN HISTORICAL SURVEY

The twenty-year war between the supporters of air-cooled and water-cooled aviation engines is rapidly dying out with the desertion of most of the water-cooling adherents to the ranks of the enemy. The air-cooled engine is very definitely in the ascendancy and apparently is shortly to become the predominant aircraft power plant. This is not at all surprising. Air is the obvious cooling medium for an aircraft engine. The interposition of the more tractable intermediate cooling medium between the cylinders and the air has been in the nature of a makeshift, serving our purpose until we could learn how to use direct air cooling.

It does not follow that the water-cooled engine must now be considered obsolete. The suitability of the air-cooled engine for all types of aircraft and all conditions of service has by no means been proved. For all conditions of service likely to be encountered at present, or in the near future, it appears now that the air-cooled engine can demonstrate its superiority. But our aviation engine development in the past has consisted simply of design refinement and utilization of better materials. There has been very little change in the fundamental operation of the engines. Whether that plan of development is continued, or some drastic fundamental changes, resulting from our present experiments with superchargers, two-cycle engines, fuel injection, and the like, are adopted, future development is certain to bring with it higher speeds, higher temperatures and consequently more exacting cooling requirements. Whether or not air cooling can keep abreast of such development remains to be seen.

The first successful aviation engines were water-cooled. The remarkable five-cylinder radial engine designed in 1901 by Charles M. Manly for Langley's experiments and the Wright Brothers' four-cylinder engine with which they accomplished their first flight in 1903 were both water-cooled. The air-cooled engines, however, were close behind. It

was with a 24½ horsepower Anzani air-cooled engine that Bleriot first crossed the English Channel in 1909.

The first Curtiss engines were air-cooled. There was no dearth of air-cooled engines nor lack of interest in the type, but the water-cooled engine, because of its relatively simple design problems and because of the enormous assistance contributed by the parallel development of the water-cooled motor-car engine, advanced much more rapidly.

The war provided impetus for the air-cooled engine. The rotary engines, the Gnome, LeRhône and Clerget, as the highest examples of air-cooled power plants, were built in enormous quantities—to be unceremoniously discarded after they had served their emergency. The rotary engines, while they performed valuable service during the war, contributed little to the advancement of the air-cooled engine. Their inherent faults—windage loss, gyroscopic effect, difficulty of control—resulted in their early demise. We can therefore safely regard the progress of the fixed air-cooled engine, both radial and line types, as representative of the development of the air-cooled engine in general. The pioneers in this work were the Renault, Anzani and Curtiss Companies.

The Renault 70 and 80-horsepower engines, while exceptionally sturdy and dependable power plants, could boast of little in the way of cylinder performance in comparison with the performance of contemporary water-cooled engines. Their performance was about what should be expected of their cast-iron, side-valve cylinders and blower cooling. An early Royal Aircraft Establishment development was the R.A.E. 4A, a 12-cylinder, vee, 140-horsepower air-cooled engine with cast-iron, side-valve cylinders. The bore of the 4A engine was 100 millimeters and the stroke 140 millimeters. The cylinder performance, 85 pounds per square inch brake mean effective pressure, although an improvement over that of the Renault cylinders,

was still considerably lower than the performance of the best water-cooled engines of the time, although the engine was extremely dependable.

The R.A.E. 4D engine, which was produced early in 1917, differed from the 4A engine principally in cylinder design. The 4D cylinder consisted of head and barrel of cast aluminum, into which an open-end steel liner was shrunk. The steel valve-seats were cast into the head. In this cylinder the side valves were replaced by overhead valves and the

entirely abandoned in air-cooled engine development until its revival by the United States Army Air Service in 1923 in the form of the air-cooled Liberty.

The cylinder studies by the Royal Aircraft Establishment continued with the design and test of a large number of air-cooled cylinders of various types and materials in sizes up to eight-inch bore and ten-inch stroke. The 4E cylinder was a modification of the 4D, with larger valves and with four instead of two hold-down bolts. Both the 4D



WRIGHT "WHIRLWIND"

upper half of the combustion chamber was of spherical form. In performance the 4D cylinder showed a marked superiority over the 4A, producing a brake mean effective pressure of approximately 108 pounds per square inch. Although the 4D engine was never put into production, the success of the cylinder indicated the possibilities of improvement of air-cooled cylinder performance by such design investigations. The R.A.E. 4A engine was the last of the air-cooled vee engines produced in any quantities, and with that engine the vee type was

and 4E cylinders, however, suffered from poor thermal contact between the steel liner and the aluminum barrel. This difficulty led to the development of cylinders with all-steel barrels, both open and closed ends, with various types of heads.

The A.B.C. cylinders for the Wasp and Dragonfly engines were constructed with a one piece, closed-end steel barrel, a flat head, valve seats machined in the steel head, two exhaust and one intake valve, and separate cast-iron and aluminum valve-ports attached by studs to

the cylinder head. As might be expected, these cylinders had very poor head cooling, the valve life was very short and the fuel consumption necessary for most satisfactory service was excessive. To correct these troubles, the R.A.E. 21T cylinder and the 21TD, differing from the 21T in details only, were designed.

The 21TD cylinder consisted of an aluminum head cast on an open-end steel barrel. The head was spherical and single intake and exhaust valves were used. The valve seats were cast into the aluminum head. Test results showed these cylinders to be much more successful than the earlier type, but difficulty was experienced in obtaining satisfactory bonding between the head and barrel. A modification of this type, in which the cast-aluminum head was bolted rather than cast to the open-end steel liner was considered unsatisfactory because of insufficient thermal contact at the joint.

A later British development, the cylinder type to which American air-cooled engine progress is most directly indebted, was the open-end steel barrel with cast-aluminum head screwed and shrunk on the barrel. In this cylinder, the valve seats were cast into the head. The spherical combustion chamber with single intake and exhaust valves was very similar to that of the R.A.E. 21TD cylinder. This type of cylinder was used first on the Siddeley radial but is now in general use in modified form in England and the United States, on all types of air-cooled engines. The British development of the air-cooled cylinder continued, of course, beyond this point, but the steps mentioned formed in general the foundation on which the larger part of the American air-cooled engine progress has been built.

During the period of the war and immediately afterward there was in the United States very little air-cooled engine development worthy of the name. However, in 1916, Charles L. Lawrance produced the Lawrance A-3, a 28-horsepower, two-cylinder, air-cooled engine used to some extent in "penguin" training machines. His model B, also produced in 1916, was a three-cylinder, radial type with cast-aluminum cylinder

head and barrel, with steel liner pressed into the barrel. His cylinder construction was very similar to the R.A.E. 4D cylinder.

In 1920, after attempting unsuccessfully to interest several other aircraft-engine manufacturers in air-cooled engine construction, the Engineering Division of the United States Army Air Service undertook a definite program of air-cooled development by the announcement of a competition for the design and construction of an air-cooled, radial engine for pursuit airplanes. Seven designs were submitted and finally a contract was entered into with Mr. Lawrance for the construction of four nine-cylinder air-cooled engines of 160 horsepower, to be known as the Lawrance R-1.

The Lawrance R-1 was delivered to the Engineering Division and successfully completed a 50-hour test in 1921, the first American air-cooled engine to successfully pass such a test. Fifty of these engines, enlarged in capacity, but identical in other details (called the Lawrance J-1), were purchased during the same year by the United States Navy for training purposes. The Lawrance R-1 engine was the starting point for the development of the first American production of air-cooled aviation engines. It has been developed over a period of five years and is now represented by the highly successful Wright Whirlwind type J-5 engine. This engine was used by Colonel Charles A. Lindbergh in his Ryan monoplane in which he made his now historic non-stop flight from New York to Paris. This engine has been described in detail in so many accounts, as to be familiar to all.

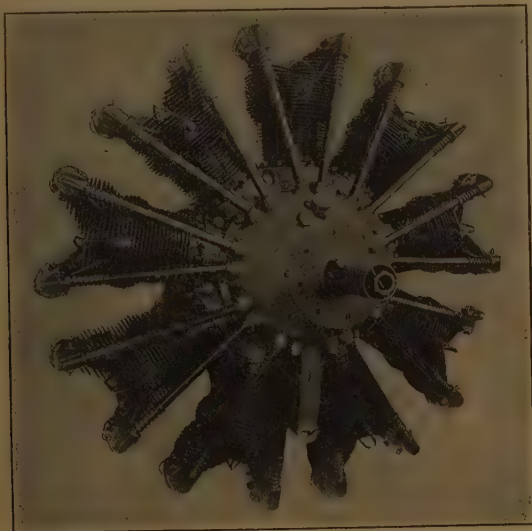
The Lawrance R-1 engine cylinder was similar to that of the Lawrance model B engine with cast-aluminum head and barrel, pressed-in cylinder liner, relatively flat head, two valves and cast-in valve seats. This general cylinder construction was continued with only detail changes until, in the J-4 model, the upper end of the cylinder liner was threaded and screwed into the aluminum casting. The cylinder construction was again changed in the J-5 model and a spherical-head cylinder, developed by the Engineering Division of

the United States Army Air Service, was substituted for the J-4 type.

In 1922 the Wright Aeronautical Corporation delivered the Wright R-1 engine, fitted with the Engineering Division type J cylinder. The first 50-hour test of this engine was terminated after 47 hours through failure of the master connecting rod. A duplicate of this rod was modified slightly, the compression ratio increased to 5.4 to 1 and the 50-hour test repeated. The second test was terminated after 43 hours through piston

failure. The engine recently passed its 50-hour test and is now in service test status. The type designation of the engine has been changed to Curtiss R-1454. This engine represents the first American application of the rotary-induction system which has since been incorporated in all of the larger air-cooled engines.

Coincident with the competition for air-cooled radial engines, the Army Air Corps initiated a series of tests of air-cooled cylinders similar to the tests conducted at the Royal Aircraft Establish-



THE "WASP"

and crankshaft failure. Following this test, the engine was rather generally redesigned and rebuilt for the third 50-hour test, which was terminated in preliminary calibration runs through piston failure.

On the basis of these tests, a contract was written with the Curtiss Aeroplane and Motor Company for three R-2 engines to be similar in general construction to the rebuilt R-1. This engine incorporated a built-in rotary induction system, type M cylinder and special crankpin lubrication system. This en-

ment. The cylinder investigation at the Engineering Division started with what now seem grotesque examples of air-cooled cylinders. The early tests were conducted largely with cylinders composed of aluminum heads and barrels cast on steel cylinder-lines. Bronze valve-seats cast into the heads were used in nearly all of the early tests. The types of construction tested included axial fins, circumferential fins, bolted-on heads, integrally-cast heads, roof heads, flat heads and other minor modifications of design. All of these types for one

reason or another were unsatisfactory and the later development has been concentrated on the cast-aluminum head screwed and shrunk onto the forged steel barrel.

The first three of the cylinders with screwed-on heads were designed to investigate the relative value of two, three and four valves and of roof-head, flat-head and spherical-head cylinders. The H cylinder was a four-valve roof-head cylinder, the I a three-valve, flat-head cylinder and the J a two-valve, spherical-head cylinder. The results of tests showed the spherical head to be superior to either of the other types from the point of view of cooling, and two valves to be entirely adequate for cylinders of this size (five and five-eighths by six and a half inches). The development was continued with the J cylinder.

It will be impossible in this article to discuss in detail the development of the air-cooled cylinder by the Engineering Division, but the principal results may be briefly stated as follows:

a. First development of high mean effective pressure air-cooled cylinders. "High mean effective pressure" in this instance refers to brake mean effective pressures in excess of 130 pounds per square inch, maintained over long periods of operation.

b. Development of the shrunk-in, aluminum-bronze valve seats. While this may appear to be unimportant, no more than a glance at the troubles that have attended the use of cast-in, rolled-in and peened-in seats and the general adoption of the shrunk-in aluminum-bronze seats in cast-aluminum heads is required to prove its value.

c. The development of the enclosed valve gear for air-cooled aviation engines. This type is represented in the K and M cylinders. The advantages are complete oil-bath lubrication of the valve gear, with consequent elimination of wear, partial compensation for valve clearance, retention of push rods when a valve spring fails, and protection of valve gear from the effects of exposure (particularly desirable in operation in the vicinity of salt water).

d. The development of a foundry practice and the commercial application

of special alloys for cylinder-head castings.

e. The investigation of valve cooling and valve materials and the development of properly proportioned salt-cooled and standard valves for air-cooled engines.

f. The vindication of the large, two-valve, air-cooled cylinder. The Engineering Division two-valve X cylinder with 188 cubic-inch displacement develops 133 pounds per square inch brake mean effective pressure at 1,800 revolutions per minute; approximately 166 pounds indicated mean effective pressure.

Shortly after the successful completion by the Wright R-1 engine of the larger part of a 50-hour endurance test, the Wright Aeronautical Corporation, at the request of the United States Navy, began the development of a large air-cooled radial of approximately 400 horsepower, designated the Wright P-1 engine. This engine employed the screwed and shrunk aluminum-head cylinder with, however, an unusual type of valve mechanism in the form of a push-and-pull rod across the top of the cylinder. The engine has been developed through several models, but its general acceptance as a service type has been delayed by a series of unfortunate incidents encountered during its experimental development.

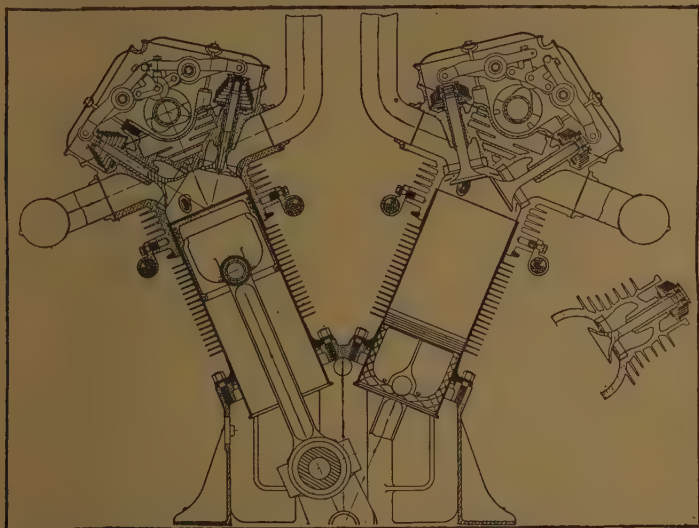
The latest entry into the air-cooled radial field, representing a very creditable bit of engine design, is the 9-cylinder, 1,340 cubic-inch Pratt-Whitney Wasp. In many particulars, this engine is superior to any air-cooled radial previously in existence. Its actual test-development-to-production status has been accomplished in a remarkably short time. Its performance characteristics, particularly in the matter of smoothness and high-speed performance, are excellent. It has a bore and stroke of five and three-fourths inches, and a piston displacement of 1,340 cubic inches. It is rated at 400 horsepower at a normal speed of 1,900 revolutions per minute and weighs, bare, approximately 650 pounds. It employs the familiar screwed and shrunk cast-aluminum head cylinder similar to the type M developed by the Engineering Division for the R-1454

engine, but with the lower halves of the rocker box integral with the cylinder-head casting. The cylinder has a spherical head, single intake and exhaust valves and shrunk-in valve seats. The crank-case is of forged duralumin and carries a built-in rotary-induction system at the rear.

No more than mention has yet been made of the revival by the Engineering Division of the air-cooled, vee engine last seen in the R.A.E. 4A engine in England. Air-cooled engine studies by

the air-cooled Liberty, with 45 degrees angle between cylinder banks, could be made to cool satisfactorily, there should be little difficulty in cooling any air-cooled, vee engine.

The first experimental engine was built in the upright type and cooled very satisfactorily through three torque-stand 50-hour tests. For airplane installation advantages, the subsequent air-cooled Liberty engines have been inverted. They have given an excellent account of themselves in flight service and, in direct



TRANSVERSE SECTION OF AIR-COOLED LIBERTY

the Engineering Division led to the belief that a high-duty, air-cooled, vee engine could be designed to operate satisfactorily and would have considerable advantage, in the larger sizes at least, over the radial type. The advantages considered at the time were reduced head area, increased smoothness, higher maximum crankshaft speeds and, chiefly in the larger sizes, installation advantage. In order to test the theory, it was decided to rebuild a Liberty engine with air-cooled cylinders and investigate its performance. It was believed that if

comparisons with the most advanced representatives of the air-cooled, radial types in similar installations, have certainly showed themselves to be at no great disadvantage.

The theoretical advantages of the air-cooled, vee engine over the radial are being confirmed by experimental results. In return for a slightly higher (at the moment) weight-horsepower ratio, the air-cooled, vee engine offers reduced head area, increased smoothness of operation, higher maximum crankshaft speeds, more readily adjustable degree

of cooling, and simplified installation problems. These advantages are increasingly important in the larger sizes. We shall probably discover before very long that some compromise between the two is more desirable than either the vee or radial, but at present the radial, air-cooled engine appears to possess the majority of the advantages in small powers, the vee in the intermediate range and the X in the high-power range (1,000 horsepower and above).

This vindication of the air-cooled, vee engine has led to the development by aircraft engine manufacturers of at least two air-cooled, vee engines now in the design stage. The success of the air-cooled Liberty engine has also led to the development by the Engineering Division of a 24-cylinder X type engine of 4,520 cubic inches displacement, rated conservatively at 1,200 horsepower at 1,800 revolutions per minute. Single-cylinder tests of the X engine cylinder have produced highly satisfactory results which indicate that the completed engine can be expected to develop its rated power at 1,600 revolutions per minute or even below that figure.

There are also in development two rather unconventional types of air-cooled radial engines, the Cam engine now being developed by the Fairchild Caminez Engine Corporation and the Kinney radial engine under development for the Navy. Both are, on the whole, very promising types, but still largely in advanced experimental status. The Cam engine is a 150-horsepower radial in which a double-lobe cam replaces the crankshaft. The cylinders are of the screwed and shrunk aluminum-head type, employing the Engineering Division type M cylinder head on a special barrel. The Kinney radial was developed at the request of the Navy for training purposes. It was originally designed as a sleeve-valve, five cylinder,

radial engine. The design was modified after preliminary tests and now incorporates a bolted-on head cylinder with an improved hydraulic (oil operated), valve gear.

The present status of the air-cooled engine in this country can be summed up rather briefly. There are two air-cooled radial engines in production status, the 400-horsepower Pratt-Whitney Wasp and the 200-horsepower Wright Whirlwind. There are two more air-cooled radial engines of approximately 425 horsepower in service test status—the Wright P series and the Curtiss R-1454. There are in promising experimental status at least five more radial engines, ranging in power from 60 to 600 horsepower. There is in service test status also one two-cylinder opposed air-cooled engine, the Wright Morehouse M-80. In the air-cooled vee and X types there are in service test the air-cooled Liberty of 430 horsepower, and in experimental status the Engineering Division 1,200-horsepower X engine and at least two air-cooled vee engines capable of developing approximately 500 horsepower.

There seems now to be no unwillingness on the part of aircraft-engine manufacturers to engage in air-cooled engine research and design. Whereas several years ago it was difficult enough to buy experimental work on air-cooled engines, today we can easily name at least six projects by nearly as many companies, which have been undertaken and probably will be carried completely through the experimental stage without support or assurance of support by aircraft engine buyers. The air-cooled engine is certainly being given an opportunity to prove itself, and present-day results appear to vindicate the work involved.—Robert Insley, Asst. Chief, Power Plant Section, Engineering Division, Air Corp.

OIL ENGINES FOR AIRCRAFT

THEIR DEVELOPMENT AND FUTURE

Making a profit out of commercial aviation is a problem which has received a great deal of attention in the last few years, and while to a certain extent it is still a question of gaining public confidence and laying out more airways, a great deal of progress in lowering the cost of commercial aviation can be made with the help of the engine builder.

During the war it was all very well to completely overhaul a Liberty engine every 100 hours and maintain a small army of mechanics and helpers to keep the planes and engines in shape, but, since the aviator has had to learn to speak the banker's language, he has discovered that flying with his Uncle Sam taught him some very bad financial habits which it has taken him a few years to grow out of.

These new economic standards and new service conditions have brought about a corresponding change in the types of aircraft and aviation engines required. The production of commercial types of airplanes and dirigibles has progressed at a very rapid pace, but the production of engines especially designed for commercial service has been hardly touched at present, particularly in the larger units.

The reason for this condition is largely the fact that the demand for the majority of new engines still comes from the military air forces and also that a large number of war surplus aero engines have been available for commercial operators.

However, the experience of the Air Mail and private American and European aircraft operators has shown that the use of power plants, built primarily to military specifications, raises the cost of fuel and of engine maintenance to a point where it is out of proportion to the other operating charges and, in some instances, is high enough to materially influence the revenue which is derived from operating present-day transport airplanes.

The record of the United States Air Mail for the fiscal year 1925 shows that,

of the total operating costs, 16 percent of the charges involved are dependent on the efficiency and endurance of the engine used. The French Air Union have found that the supply of fuel and lubricating oil and the maintenance and depreciation charges on the engines amount to over 25 percent of the total operating costs of an air-line operating on a regular daily schedule.

It is, therefore, very apparent that any improvements in the fuel economy, endurance and general operating efficiency of the airplane engine will have a most important bearing on the cost of air transport in general.

Of course, the production of an oil engine for aircraft is still a project which is subject to some rather complex design problems, but any discussion of experimental work of this type is always clarified by a full appreciation of the opportunity which will exist for the finished product. The oil engine designer will not be called upon to bridge the entire gap which lies between the present types of oil engines and the aircraft engines in use today, as the commercial aviator is rapidly changing aero engine standards to a point where the accomplishment of a practical aviation oil engine is not such a radical step as it first appears to be.

Hence, the introduction of this new set of standards into aviation power plant practice not only places the achievement of a heavy oil aviation engine in an entirely different light, but also indicates the possibility of the oil engine rising to position of preference for certain classes of long-distance transport aircraft.

In the following discussion the requirements are primarily outlined for airplane and seaplane engines, but it is safe to assume that if the oil engine can approach these specifications it will also be possible to adapt it to the somewhat different demands encountered in the design of engines for use in dirigible balloons.

In the present military type aviation

engine first cost and maintenance cost are of secondary importance; for air transport these charges should be as low as possible. The life of a military engine is also a relatively minor consideration, while in commercial service the life of the engine should be as long as possible.

The weight of the military aviation engine must be reduced to the absolute minimum, several such engines being in the neighborhood of 1.5 pounds per horsepower, but it will not seriously affect the weight-carrying capacity of the transport airplane if the weight is not over 2.5 pounds per horsepower, and it is quite practical in dirigibles to have a weight as high as 4.5 to 5 pounds per horsepower. This affords considerably more latitude for the oil engine designer.

Transport engines are needed in units of 200, 400 and 600 horsepower, while a propeller speed of from 1,200 to 1,500 r.p.m. is amply sufficient. As a matter of fact, the lower range of propeller speeds, from 800 to 1,500 r.p.m. are considerably more efficient than the speeds of 1,400 to 3,000 r.p.m. which are encountered in the majority of aircraft engines at present in use.

The military engine is expected to operate constantly at full throttle, while the transport engine is run at from 75 percent to 85 percent of the rated maximum output under ordinary cruising conditions. The altitude performance required of the commercial airplane is also very much less rigorous than that encountered in war service, airways planes usually flying at an altitude of from 2,000 to 8,000 feet, depending on the weather conditions.

Safety is of the utmost importance in the transportation of passengers and mail by air, if there were no other advantages which could be claimed for an aero oil engine, the freedom from fire risk achieved would be a very strong justification for its use.

The fuel consumption of the oil engine and the gasoline engine is theoretically in the order of 2 to 3, and when the fuel consumption in comparison with the total weight of the power plant and fuel is computed, assuming an aero oil engine weighing not more than three pounds per horsepower, the performance

of the oil engine begins to compare favorably with that of the present gasoline engine when flights of over 300 miles are approached. As the comparison is continued a point will be reached when the fuel economy of the oil engine will be superior to that of the gasoline engine; with present types of airplanes cruising at 100 miles per hour this point has been tentatively set at from six to eight hours flying time.

Since the cost of operating passenger aircraft at present becomes almost prohibitive for flights of longer than four hours duration this analysis should indicate that the use of a hypothetical oil engine would materially reduce the charges involved, not only in long flights but in any air journey over 300 miles, as the much lower cost of Diesel fuel would also be an important factor in lowering the expense.

For very long flights with dirigibles the balance in favor of the oil engine is even more important, in addition to the vital necessity for obtaining a non-inflammable fuel. These advantages have been felt so strongly by the British Air Ministry that it has been decided to install Beardmore heavy oil engines in one of the new dirigibles which is being built for the Royal Air Force. No details are as yet available in regard to these engines, but an unofficial announcement places their weight at three pounds per b.h.p., which is considerably less than the weight of the Maybach gasoline engine used in the *Los Angeles*.

Accessibility, simplicity and ability to operate for long periods of time without overhaul are also of great value to the air transport operator, while they occasionally have to be sacrificed by the Air Corps to achieve more important aims. The elimination of electrical ignition and of sensitive carburetor adjustments which would result from the use of the oil engine would alone be important advances.

It will thus be seen that an aero oil engine built in accordance with the new commercial aviation requirements will have a very definite field of usefulness, and it is possible that the production of such an engine will be of considerable assistance in increasing the reliability and economy of transport aviation.

Considerable work has been done along these lines by various agencies in this country and abroad, and although there is still a great deal of ground to be covered, the technical problems to be solved have been clearly defined.

These can be summarized under the following general heads—combustion, fuel injection and structural design. The National Advisory Committee for Aeronautics has embarked on a very complete program of investigation of the conditions encountered in attempting the practically instantaneous auto-ignition of fuel in small combustion chambers of various forms, and they have also studied the effect of variation of the compression ratio on the N. A. C. A. Test Engine.

Some of these tests have shown that with a compression pressure of 420 pounds only one revolution is necessary to start with a cold engine. This is rather a contrast to the endless "warming-up" encountered with the ordinary airplane engine, especially in cold weather.

Using a cam-operated fuel pump a speed range from 150 r.p.m. to 1,200 r.p.m. has been obtained, and the one-cylinder test engine has idled satisfactorily at speeds below 150 r.p.m.

Fuel spray and injection valve characteristics have also been studied by the National Advisory Committee and the results are now available. The work of this laboratory is a very important contribution to the development of the high speed engine and is especially interesting in this discussion because it has been undertaken by a laboratory which is directly concerned with the solution of aviation power plant problems.

The Beardmore Company, under the direction of Mr. Alan Chorlton, has produced several high speed engines used on rail cars which develop about 400 b.h.p. at 750 r.p.m. The weight of these units average 15 to 20 pounds per b.h.p., but, as mentioned before, the Beardmore Company has carried this work to a point where engines suitable for use in dirigibles are at present in course of construction.

Mr. Chorlton places the weight of these engines in the neighborhood of three pounds per b.h.p., and in a recent

address before the Royal Aeronautical Society he predicted the practical utility of the oil engine for use in airplane flights of over 300 miles.

The Beardmore Aero Oil Engine probably follows the general practice which has been followed in the heavier Beardmore Oil Engine, that is, a cast steel multicellular crank-case construction with steel cylinder liners. A solid injection fuel system is applied after a method patented by the designer, in which the fluid column is kept in steady fluctuation by a constant stroke plunger with delivery to the jets controlled by a rapidly moving flash valve on the supply side of the fuel pump.

The following requirements for rapid fuel injection outlined by Mr. Chorlton, which comprise

1. A definite injection period
2. Precise measurement of fuel
3. Instantaneous cut-off of the supply
4. Fine division to permit sufficiently rapid combustion
5. Prevention of impingement on the walls of the combustion chamber,

have been very adequately met by this method, and in combination with the construction used, Mr. Chorlton's work also marks a very important advance.

The Attendu Oil Engine has received some attention from our Navy Department, which seems to be the branch of our fighting air forces taking the most interest in aviation oil engine work. Several models of Mr. Attendu's engine have been built, and it has been supplied with considerable success to heavy motor trucks.

An experimental aero type Attendu engine was tested by the Navy Department about a year ago with such promising results that it is understood that a further refinement of the same engine is being prepared. The aviation test engine was a two-cycle, solid injection, two-cylinder model, built of steel and aluminum and developing 85 b.h.p. at 1,620 r.p.m., although better test results have been obtained since then. The weight per b.h.p. hr. has been reduced to 3.6 pounds and the fuel consumption is 0.5 pound per b.h.p. hr.

Port scavenging of the exhaust gases is controlled by placing an exhaust valve

in a housing outside of the exhaust ports, which permits a better control of the compression pressure built up after the exhaust gases have been completely eliminated. A large diameter, short stroke air compressor is mounted on the side of the engine with a rotary valve immediately above it, and two intake valves, operated by an overhead camshaft, are located in the aluminum cylinder head.

A compound fuel pump with a variable timing control is fitted and a speed range of from 120 r.p.m. to 2,210 r.p.m. has been attained.

The Maybach-Zeppelin High Speed Diesel Engine is another very interesting development which has been undertaken by the builders of the engines used in the Zeppelin dirigible balloons.

This engine adheres very closely to the design practice current in the larger dirigible engines built by the same manufacturer and is a four-cycle, air-injection, 6-cylinder type, developing 150 horsepower at 1,300 r.p.m.

The weight of the unit is slightly over 17 pounds per b.h.p., but as the cylinders and crank-case are cast of gray iron, it would probably be possible to reduce the weight considerably by adapting aero engine construction more completely to this design.

The Maybach engine in its present form is well adapted to use on rail cars and motorboats, and there was some talk of the use of similar engines on one of the new Zeppelins, but since Dr. Eckner has been experimenting with the use of gaseous fuel for his new dirigibles, it looks as if this project had been deferred.

A high-speed, light-weight oil engine built after Benz design is being produced by the English McLaren firm, and although no details are at present available in regard to this engine, it probably embodies the well-known combustion chamber design used in the heavier Benz engines. The McLaren Benz oil engine when built of aluminum weighs 26 pounds per b.h.p. and develops 60 b.h.p. at 800 r.p.m., which performance is comparable to some of the American types of semi-portable engines which are used on excavating equipment.

Work in this field has also been done

by the Pucgot Company, by Bagnulio, the Italian designer, and by Deutz, but these engines are primarily hot-bulb types and are for this reason unsuited for consideration for aviation service.

Considerable attention has been devoted to the problem of aero oil engines by Mr. Elmer G. Sperry of the Sperry Gyroscope Company, and his method of attack differs considerably from the work done by some of the other designers. Mr. Sperry has largely confined his efforts to the production of an engine which will permit the use of a much higher mean effective pressure than is ordinarily used.

This has been proposed by the use of a high initial supercharging pressure combined with two-stage expansion which continues the power impulse of the expanding gases through a larger arc of the crankshaft revolution than is possible in oil engines which exhaust direct into the outer air.

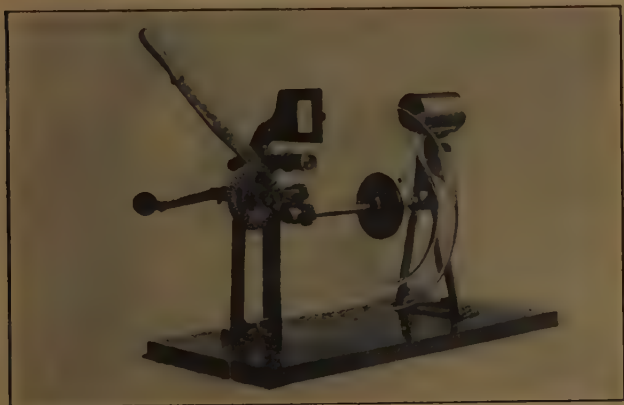
Preliminary tests have developed a mean effective pressure as high as 300 pounds and a correspondingly high maximum pressure. Whether it will be possible to operate with pressures as high as these and use orthodox aero engine type of construction is a question which will be answered very shortly, as the Sperry Company is now preparing to build a 250-horsepower aviation engine along the lines described.

Several other American manufacturers have produced various types of light-weight oil engines which have been suitable for use on mobile equipment, such as contractor's shovels and draglines. Among the most active in this field have been the Atlas-Imperial Engine Company, The Cummins Engine Company, The Hill Diesel Engine Company and the Foos Engine Company. Some very interesting work in light-weight construction has also been done by Mr. H. F. Shepherd of the Bessemer Gas Engine Company, although his efforts have been mainly confined to the larger units.

Even a brief study of the progress made to date shows that a considerable advance has been made in defining the problems which must be solved, in developing the experimental technique for furthering their solution and in acquiring

ing the support which is necessary to pursue such an object; and it is to be hoped that the liberalizing influence of the new commercial aviation requirements will be a constructive force in eventually bringing forth a type of avia-

tion power plant which even at this stage of its development gives promise of being an important future factor in the extension of our air transportation facilities.—*Roswell H. Ward, Associate Editor, Oil Engine Power.*



A HIGH SPEED CAMERA MECHANISM FOR THE ANALYSIS OF MOTION



JENKINS MOTION-PICTURE CAMERA OF 1895

RADIO

MARCONI'S OWN STORY

BIRTH

Twenty-five years ago last December 12, 1926, Guglielmo Marconi, waiting with every nerve and sense taut in an old, dilapidated building on the coast of Newfoundland, received the first signal ever transmitted by wireless across the ocean. That signal proved that his dream of linking together the nations by a method of communication infinitely more mysterious and more uncanny than any hitherto discovered had at last been snatched once for all from dreamland and ranked among the solid facts of existence.

Today the Italian wireless wizard, still modest and retiring despite the overwhelming fame which his discovery has brought him, gives for the first time his own personal account of those wonderful moments of a quarter of a century ago. It was the privilege of *The New York Times* representative to obtain from Senator Marconi himself this personal narrative, describing the arduous preparations, trying hours of suspense and glorious thrill of achievement when the instrument devised by him—how primitive it would seem today—ticked off on that lonely Newfoundland shore a message from Cornwall, England, three thousand miles away, which told him and the whole world that his marvelous child of science, until then reckoned merely a "child prodigy," was a full-grown reality, with an illustrious future shining before it.

Senator Marconi describes it all seated in the big sumptuous London offices of his wireless company, though twenty-five years ago he and the other dreamers of big dreams were in cramped and unassuming quarters.

SENATOR MARCONI'S NARRATIVE

"On December 12, 1901, in a room of a disused barracks on Signal Hill, St. John's, Newfoundland," he said, "on a table stood some instruments connected by a thin wire with a kite that was held up at a height of about 400 feet by an

Atlantic gale. To the same instruments there was connected a telephone, in which shortly after noon were heard sounds constituting evidence that in far-distant Cornwall rhythmical signals that corresponded to the letter S in the Morse code had been projected into the ether of space and had actually crossed the Atlantic.

"In 1895 and 1896 I had proved the possibility of transmitting signals to a considerable distance by means of raised antennae and an earth connection. In 1899 I had proved that the curvature of the earth did not interfere with a propagation of ether waves over short distances and in 1909 I felt that the time had come to venture further afield. Having regard to the many improvements I had lately introduced into the methods of tuning the transmitter and receiver, I was absolutely convinced that transatlantic wireless telegraphy, not merely as an experiment but as a sound commercial proposition, was possible. Naturally, I realized that my first endeavor must be directed to prove that an electric wave could be sent out across the Atlantic and detected on the other side.

"A wireless station was built at Pol-du, in Cornwall, for this purpose. An aerial system was built, supported by a ring of twenty masts, each about 200 feet high, arranged in a circle 200 feet in diameter and covering an area of about an acre.

"By the end of August, 1901, the erection of the masts was nearly completed. And then, unfortunately, a terrific gale swept the Channel and English coast, with the result that one of the legs of the weather topgallant mast cap was broken and the whole construction wrecked.

"Naturally I was extremely disappointed, as, owing to the nature of the coast at Mullion and the special character of the work, some time must elapse before the damage could be repaired. For some days I had visions

of my experiment having to be postponed for several months or longer.

"Then I decided it might be possible to make a preliminary trial with a simpler aerial. Therefore, ten of the masts, each 170 feet high, were re-erected. A triangle stay was stretched between the two end masts, and from this triangle stay were suspended sixty almost vertical bare copper wires, the distance between the wires being about one meter at the top. These wires converged at the bottom, making an aerial in the form of a fan.

"In the middle of November I was able with this temporary aerial to obtain signals of such great strength, at what was then my most distant station, Crookhaven, Ireland, that I felt sure they would be detectible at a ten times greater distance.

THE FIRST WORK IN NEWFOUNDLAND

"On November 26 I sailed from Liverpool on the Allan liner *Sardinian*, accompanied by my two assistants, G. S. Kemp and P. W. Paget. As it was quite impossible at that time of year, owing to inclement weather and especially in view of the shortness of the time at our disposal, to erect high masts to support an aerial, I had arranged to have the necessary aerial supported in the air by a small captive balloon, and so we took with us two balloons and six kites.

"We landed at St. John's on Friday, December 6, and the following day, before beginning operations, I visited the Governor, Sir Cavendish Boyle; the Premier, Sir Robert Bond, and other members of the Ministry, who promised me their heartiest cooperation and placed the resources of every department of the Government at my disposal in order to facilitate the work.

"After taking a look at various sites which might prove suitable, I considered the best one was on Signal Hill, a lofty eminence overlooking the port and forming a natural bulwark which protects it from the fury of the Atlantic gales. On top of this hill there is a small plateau some two acres in area, which I thought very suitable for manipulation of either the balloons or kites. On a crag on this plateau rose the new

Cabot Memorial Tower, which was designed as a signal station, and close to it there was the old military barracks, which then were used as a hospital. It was in the forum in this building that I set up my apparatus and made preparations for the great experiment.

"On Monday, December 9, I began work on Signal Hill. On Tuesday we flew a kite with 600 feet of aerial as a preliminary test, and on Wednesday we inflated one of the balloons, which made its first ascent during the morning. Its diameter was about fourteen feet, and it contained some 1,000 cubic feet of hydrogen gas, quite sufficient to hold up the aerial, which consisted of wire weighing about ten pounds. Owing, however, to a heavy wind, after a short while the balloon broke away and disappeared. I then came to the conclusion that perhaps the kites would answer better, and on Thursday morning, in spite of a gale, we managed to fly a kite to a height of about 400 feet.

THE CRITICAL MOMENT

"The critical moment had come, for which the way had been prepared by six years of hard and unrelenting work, despite the usual criticisms directed at anything new. I was about to test the truth of my belief.

"In view of the importance of all that was at stake, I had decided not to trust entirely to the usual arrangement of having coherer signals recorded automatically through a relay and Morse instrument on a paper tape, but to use instead a telephone connected to a self-restoring coherer, the human ear being far more sensitive than the recorder. Suddenly, at about half-past twelve, unmistakably three scant little clicks in the telephone corresponding to three dots of the Morse code sounded several times in my ear as I listened intently, but I would not be satisfied without corroboration.

"'Can you hear anything, Mr. Kemp?' I said, handing the telephone to my assistant.

"Kemp heard the same thing as I, and I knew then that I had been absolutely right in my anticipations. Electric waves which were being sent out from Poldhu had traversed the Atlantic

serenely ignoring the curvature of the earth which so many doubters considered would be a fatal obstacle, and they were now affecting my receiver in Newfoundland.

"I knew then that the day on which I should be able to send full messages without wires or cables across the Atlantic was not very far distant, and as Dr. Pupin, a celebrated Serbo-American scientist, very rightly said shortly afterward, the faintness of the signals had nothing to do with it.

"Distance had been overcome, and further development of the sending and receiving apparatus was all that was required.

"On the following day signals again were heard, though not quite so distinctly. However, there was no further doubt possible that the experiment had succeeded.

"Following the success of my experiment I was notified on behalf of the Anglo-American Telegraph Company, that as they held a charter giving them the exclusive right to construct and operate stations for telegraphic communication between Newfoundland and places outside the colony, the work upon which I was engaged was a violation of their rights. I was asked to give an immediate undertaking not to proceed with my work and to remove my apparatus or legal proceedings would be taken.

"I was absolutely astounded at this communication, which, however, at least gave satisfactory assurance that one of the great telegraph and cable companies not only believed in but also feared the possibility of wireless trans-Atlantic communication. I will say nothing further on this matter now, and only mention it in order to show why my experiments were cut short on that occasion, and why I was forced to abandon a demonstration which I had intended to give on the following Monday on Signal Hill to the Governor of Newfoundland, Sir Cavendish Boyle, and a number of other gentlemen who were highly interested in the results of my experiments.

"When the reason for my discontinuing my experiments became known I was almost deluged with offers of

sites for the erection of experimental and permanent stations. Among others, Mr. Fielding, Finance Minister of the Government of Canada, offered me on behalf of that Government every facility for the location of a station in Nova Scotia, which I decided to accept.

"I arrived in England again on January 26, 1902, and on February 22, I sailed for the United States, en route for Canada, where I was due to sign a final draft of agreement for the erection of a large wireless station at Glace Bay and to put in hand the construction of that station.

"Before leaving I arranged for the Poldhu Station to send out a program of signals for me to receive on the ship during the voyage. On this voyage I was able to receive complete messages up to 1,551 miles, and single letters to 2,099 miles. Thus, within three months of receiving single letters at 1,800 miles, I was receiving complete messages at 1,500 miles.

"I was thus able to prove what I had set out to prove, that wireless communication could satisfactorily be carried out between countries separated by large stretches of ocean. By December, 1902, it was possible to exchange messages at will between the station I had erected at Glace Bay and Poldhu.

"Wireless telegraph communication over long distances was thus proved to be a reality and not a dream.

"Naturally, it is very gratifying for me, after a lapse of twenty-five years to look back upon those experiences and mediate upon the far-reaching effects that followed those early beginnings. It is a pleasing coincidence that almost exactly, on the twenty-fifth anniversary I have been able to bring to fruition another far-reaching development in long distance wireless communication in the establishment of short-wave stations, which constitutes practically a revolution in wireless communication."

Asked for his views regarding the possibilities of wireless during the next twenty-five years, Senator Marconi said:

"Twenty-five years ago the instruments we had at our disposal were very crude compared to those we have today. We had no tubes, no amplifiers, no sensitive super-heterodyne sets, no di-

rectional transmitters and receivers, and no means of making continuous waves. All we had for transmitting was the means of making crude damped spark waves, which did not permit of the correct tuning we have today.

"The spanning of great distances now is child's play compared to what it was then. If those who now think nothing of intercepting signals from the other side of the world had to work with the relatively insensitive apparatus I had in Newfoundland, they would find themselves faced with a very different problem.

"During the next twenty-five years there will probably be almost as great developments in the means of obtaining directional wireless transmission and

reception as there has been in other directions during the last twenty-five years.

"As to the application of wireless in the future you know I am always averse from entering into the realm of prophecy, but perhaps I might suggest that, apart from the ordinary transmission and reception of wireless messages of which I have spoken, there is a possibility that the transmission of power over moderate distances may be developed, and that television will become an actuality.

"I must leave to your imagination the uses which can be made of these new powers. They will probably be as wonderful as anything of which we have had experience so far."



THE DEVELOPMENT OF FUEL TECHNOLOGY HAS NOW REACHED A POINT WHERE PULVERIZED COAL IS BEING USED ON STEAMSHIPS

TELEVISION

ITS DEVELOPMENT

The radio age is upon us. The electrical age, acknowledged by authorities to be still in its infancy, has been surpassed by the meteoric progress of the art of radio. This progress has in its scope the perfection of one most important invention to humanity—the art of television.

Like the development of the moving pictures, television will follow the perfect transmission of photographs. Just when can be only a matter of time.

At present there are several means of transmitting photographs from one point to another by wire, cable or radio. The various systems of themselves offer no solution to the problem of transmitting moving pictures. Nor has any one as yet proposed what appears to be a commercially feasible and practical solution. From a logical viewpoint just what is the seemingly impossible barrier? Let us consider the systems.

CASELLI'S 1856 METHOD

The outstanding advantages of the Belin system, the Bartlane, Hanson, American Telephone and Telegraph, Leishman, Korn, Radio Corporation of America or Jenkins system as compared to one another, are evident from a brief résumé of their characteristics.

As early as 1856 Caselli sent various designs by telegraphy, using for the transmitter a tinfoil-covered cylinder on which the designs were drawn in insulating compound. A needle acting very much like the stylus of a phonograph served the purpose of a contact pin, traveling spirally over the surface of the revolving cylinder. Thus the circuit was made and broken as the lines passed under the contact pin, while at the receiving end, by an electro-chemical action, a similar cylinder synchronized with the transmitter reproduced the designs directly.

EFFECT ON SELENIUM

The discovery of the effect of light on the electrical resistance of selenium became known in 1873 and shortly after-

wards various schemes to substitute selenium for Caselli's process were attempted. The most noteworthy were those of Semlocq and Perosino in 1878. After quite a lengthy interval Korn (in 1904) employing Semlocq's plan with several modifications, succeeded in transmitting photographs a few hundred miles. The method now in use by the Radio Corporation of America is to place a negative of the photo on a glass cylinder. On this is focused a very narrow beam of light used as a stylus. By reflecting the varying intensity of the light passing through the cylinder the registry is effected and then follows an amplifier system which then allows the photo to be reproduced in several ways: either by a tape recorder which records the photo as a continuous line of dots and dashes; by means of a relay which operates a special pen and reproduces a pen and ink sketch, or by means of photographic reproduction, a light shutter being controlled by the current variations and controlling the light from a lamp focused on a sensitized rotating cylinder.

BELIN FULL OF ORIGINALITY

With such a system successful photo transmission has been accomplished by radio transmission from London to New York.

The first photo which was transmitted over the Atlantic was sent by a system based upon the half-tone method of screening. The photo was automatically divided into a predetermined number of dots per square inch. A photo-electric cell then determined into which of eighteen groups a dot belonged, each group being given a distinguishing letter. By means of special relays, the letter was automatically transmitted and at the receiving station, the letter was converted into a dot and placed into its proper position in the photograph. Even though the photo was converted into 12,000 squares, much of its detail was lost. A more nearly perfect system is the Leishman process which employs a similar

but modified principle and operates on transatlantic cables.

Perhaps the most original scheme is that developed by Belin. His process resolves itself upon the fact that bichromated gelatin becomes insoluble under strong light.

Thus he places a film of wet gelatin under a negative whereupon the portions of the film swell up more or less in proportion to the intensity of exposure. This forms a sort of relief map of the negative and is wound on a cylinder over which a stylus traces its path. A microphone attached to the stylus varies the resistance of a local circuit which is coupled to a transmitter. At the receiving station an oscillograph has its mirror deflected, altering the projection of a beam of light focused on a synchronized rotating cylinder having a sensitive photographic film on it.

HOW JENKINS DOES IT

The Jenkins method of analyzing is based on aberration by means of prismatic rings. These rings are of glass, the edges ground in such a manner that a beam of light passing through is given an oscillating motion. By means of two such rings geared at a predetermined ratio, a negative is explored in minute strips, and a photo-electric cell employed to convert light into electrical values.

The Bartlane system is a coding process which operates by a printing telegraph. Holes are punched into a tape and reproduced at the receiving end by passing the tape in front of a beam of light. Synchronism is maintained by holes punched into the tape alongside the coding group.

By this time you may have noticed that there are two distinct classes into which we can place photo-transmission—the purely physical transmission, such as the Bartlane, Leishman and Korn systems, and the purely modulated electrical or radio transmission, such as the Radio Corporation of America, Jenkins,

Belin and American Telephone and Telegraph systems.

CHANCES FAVOR ONE

Of these the modulated systems stand the better chance of development into practical television. It is, however, very doubtful that any one system will not be radically changed so this may be realized. Near perfection has been achieved in single photographic transmission. The average time it requires to transmit a good picture is about ten minutes. Since all the systems require that the photo be analyzed into minute strips—about 1/100" wide, this precludes the possibility of resolving the same procedure into a practical solution of the problem.

For motion pictures we need sixteen pictures per second. Our nearest approach to television is one picture every ten minutes, unless recent claims from London of ten every second are correct. There is such a wide gap that all methods proposed up until the present time have failed to offer a practical solution.

However, with such marvelous inventions as the photo-electric cell, the Thallide cell (one converting the light energy into electrical energy, the other acting as a varying resistance controlling the current in the circuit), the Moore lamp capable of responding to very high frequencies and which may play an important part in future development work, and the prismatic rings of Jenkins, we may expect a swifter solution.

The present day receiver is so far advanced in engineering design that it will not be obsolete for many years to come. Thus, it may be entirely possible to equip the set with a "televisor," as we can aptly call the device, and have at our leisure and pleasure, not only all the latest news and best entertainment, but also the very portrayal of the events as they transpire!—*Albert W. Franklin, Chief Engineer Charles Freshman Co.*

ITS PRACTICAL DEMONSTRATION

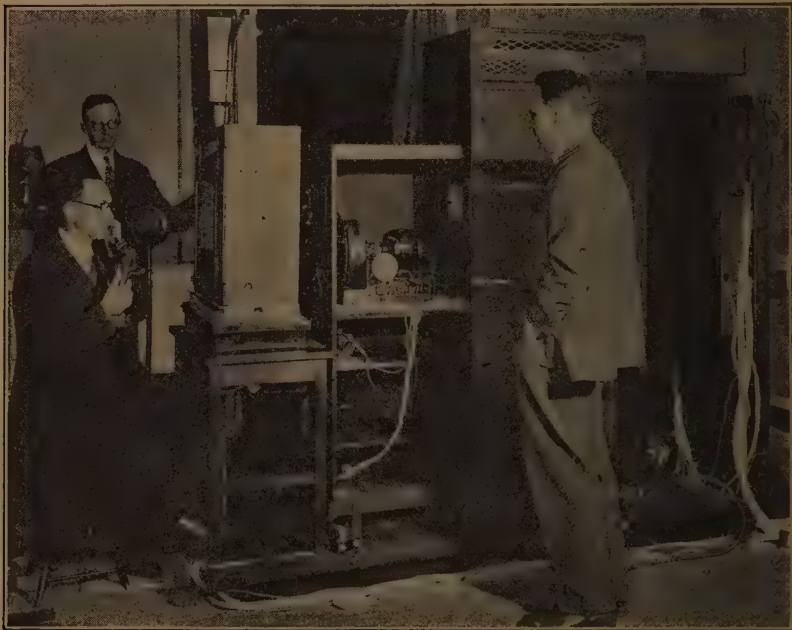
Ever since science has made it possible for the human voice to be transmitted to a distance and faithfully reproduced, inventors have dreamed of

doing the same thing with pictures or other objects. For several years it has been possible to transmit ordinary photographs by wire and radio, but the prob-

lem of sending motion pictures or images of actual moving objects has been found to be far more intricate. However, the solution has been found, and during the spring of 1927 the results of intensive research and development work were shown by the Bell Telephone Laboratories.

screen in New York. All facial characteristics, the play of emotions and in fact every detail at the Washington terminal were plainly seen by the watchers in New York.

Three telephone lines to Washington were used—one for transmitting the voice, one for transmitting the television



TELEVISION TRANSMITTING APPARATUS

VOICE AND IMAGE PERFECTLY SYNCHRONIZED

In the first demonstration, two-way telephonic communication was maintained between New York and Washington, D. C., and the images of the various persons at Washington were sent by the new process to the New York terminal of the wires. Secretary Hoover, in Washington, opened the demonstration, and his voice synchronized perfectly with the illuminated image of himself that was cast on a

current, and the third for the synchronization of the electric driving-motors at each end of the lines. The three lines operated at considerably different energies.

A brief description of this seemingly uncanny performance necessarily can only outline the principal mechanical features. It cannot include the details of the multiplicity of controls, amplifiers and regulators that are most essential and which, to the uninitiated, would seem like a hopeless maze of apparatus.

The main operating unit at the transmitting end is a light of high intensity, enclosed in a light-proof compartment. Rays from this light are emitted through fifty holes in a disk. These are spirally arranged so that one complete revolution of the disk will completely cover with spots a screen or object upon which the rays are focused. As the disk is revolved at the rate of fifteen times each second, it will be evident that the screen surface will be completely over-run by spot flashes fifteen times per second. On the receiving end is a duplication of this apparatus; both the sending and receiving motors are synchronized, or timed, by an ingenious mechanism so that they run at speeds which are uniform within one hundred-thousandths of a second. The time of transmission of each separate image is less than one-fifteenth of a second.

If, now, on the sending end, the spots of light fall upon an object which has variation of color, such as the human face, light will be reflected from the object in varying intensities, according to the degree of lightness or darkness of the minute place on the object upon which each spot of light falls. When this is accomplished fifteen times each second, it will be apparent that the entire object has reflected light spots of varying intensity with such rapidity as to excel by a wide margin the rapidity of sight, so that the optical effect, due to retention of vision, is one of continuity. In reality, the spots of light on the object seem to be a continuous flood—only a shimmering effect is noted.

TELEVISION ANALOGOUS TO EYESIGHT

As the spots of light fall on the object, the varying degrees of reflected

light are picked up by three of the largest photo-electric cells that have ever been built. These impulses, so picked up, are amplified and intensified five thousand billion times and sent over a separate wire to the receiving end. Here is a receiving screen made of a mosaic of small neon-gas bulbs, each bulb connected by a wire to a distributor which feeds to it just the amount of impulse that has been reflected from the corresponding spot on the object at the other end. These bulbs, therefore, will each glow with an intensity varying in degree according to the lightness or darkness of the same spot on the object and this, occurring fifteen times a second, gives an optical impression of continuous reproduction.

The analogy of television with the function of sight of the eye is exceedingly close. The surface of the retina is composed of infinitesimal spots which are individually connected and run back to the optic nerve. So the surface of the receiving screen is composed of 2,500 individual neon-gas light squares, each square connected by a wire that runs back to the distributor which picks out and transmits to that wire the impulse which the original image has caused to be sent.

The present demonstration is without question a marvelous scientific accomplishment. But the intricate and costly units involved, the organization and multiplication of individual controls at each step of the operation, together with the necessity of tremendous resources of expert men, money and materials, renders entirely imaginative any prediction as to the commercial possibilities which this demonstration portends.—*The Editor.*

TELEPHONE INVENTION

CLAIMED BY FRANCE

Apropos of the fiftieth anniversary of the invention of the telephone by Alexander Graham Bell, it has been recalled in Paris that in France it is a Frenchman, Charles Bourseul, and not Bell, who is officially recognized as the inventor of that instrument. Bourseul, who died in 1912, is credited with having enunciated the principle of the telephone more than twenty years before Bell discovered it. He is also said to have constructed a rudimentary telephone in advance of the American.

Bourseul, an employe of the telegraph service, which then, as now, was under Government management, wrote in 1854 an article entitled, "The Electrical Transmission of the Spoken Word," which appeared in *L'Illustration* in August of that year. In it he discussed the practicability of the telephone. The article was signed merely with the initials of the author, presumably because he was a Government employe.

Shortly afterward Bourseul sent a copy of the magazine article, together with a telephonic apparatus that he had built, to the officials charged with the administration of the telegraph lines. The response came quickly. Bourseul was advised to give his attention to "more serious things." Thus rebuked and fearing he might lose his job if he pressed the point, Bourseul let the matter rest there. Thus, according to French commentators, bureaucratic stupidity retarded for more than two decades the perfection of the telephone.

Meanwhile the published article attracted the attention of certain scien-

tists who recognized the merits of the ideas Bourseul advanced. Several scientific works of the 1860s and 1870s made reference to it, and a book published in New York in 1872 under the title, "The Wonders of Electricity," described the Bourseul system in popular terms. For this reason it is contended in France that Bell probably was acquainted with the work of Bourseul when in 1876 he constructed his telephone and exhibited it at the Exposition in Philadelphia.

Of Bourseul, half forgotten even in France, M. Deletête, Secretary General of the Department of Posts and Telegraphs, observed recently:

"He was a great man who was unknown. The department has in part made recompense for its culpable neglect of the past in rendering homage to him. With the aid of a large number of subscriptions collected in the department, a committee, of which M. de Monzie, Senator from the Lot, was President, had a statue erected in his honor at Saint-Céré, where he died in 1912 without having profited from his invention.

"The memory of Bourseul ought to be honored upon the anniversary of the telephone, and there should be a pilgrimage to his monument. I have suggested that the Department of the Lot and the town of Saint-Céré arrange for a local fête in his honor."

The telephone system of Paris was inaugurated in 1879 by a private corporation and taken over by the State in 1890. It works scarcely better now than it did then.—*New York Herald Tribune*.

THE MICROPHONE

WHO INVENTED IT?

Edison has had a rival for many years! This is not news to strictly scientific circles, but the general public was somewhat surprised when the following item appeared recently in a New York society journal:

"A coincidence that is going to interest a lot of people in general and two men in particular is the appearance this fall (1926) of the biographies of two rival inventors, Thomas A. Edison and Emile Berliner, both of whom have several world-renowned and universally used inventions to their credit. While the name of Berliner has not been heralded quite as widely as has that of Edison, it is predicted that the two books will disclose to the public some rather racy reading. It is said that Berliner, the inventor of the microphone or telephone transmitter, filed a preliminary patent for this instrument on April 14, 1877, and that Edison applied for a patent on a similar device about two weeks later. Edison has always claimed the talking machine as his favorite invention, but Berliner is the inventor of the modern or disc talking machine; and now, just to add to the gaiety of things, someone has dug up an old American newspaper which, under date of February 5, 1890, coldly and boldly remarked that: 'A dispatch from Berlin conveys the intelligence that Thomas A. Edison, the inventor of the phonograph, has been beaten in competition in that city by a man named Berliner, with a talking machine called the gramophone. The sad intelligence is in a manner softened, however, by the fact that Berliner is an American citizen, and is a resident of Washington.'"

Gossip has it that neither of these inventors knew that the biography of the other was due to appear this season until both books were already on the press; in consequence there failed to transpire that sort of thing which is known as a gentleman's agreement.

FIRST COMPLETE STORY OF LIFE

Since the Berliner biography, which happens to be written by the well-known

Washington correspondent and author, Frederic William Wile, has appeared on the book market it is found to contain the first complete and authentic story of the life and work of this inventor, whereas the Edison biography, above referred to, written by George S. Bryan, is only an addition to the Edison library of some sixty volumes, nearly a score of which are Edison biographies of one kind or another.

To the scientific and inventive world Berliner is best known for his inventions of the telephone transmitter or microphone and for the lateral cut-disc talking machine. The highly important and indispensable continuous current transformer is another invention patented by Berliner as far back as January, 1878; yet Edison biographers give the latter credit for both the microphone and the continuous current transformer. Two attempts recently made to get the Edison laboratories at Orange, N. J., to give the date on which Edison patented the transformer appliance were of no avail. The fact seems to be that Edison never patented it, because Berliner got his patent first. And there was never any other claimant in the patent office.

Berliner is also the inventor of the gramophone (in this country known directly as the Victor talking machine) and he coined the name "gramophone," a term which, as travelers know, is used in all countries but the United States to denote any form of disc talking machine. Since the Berliner patents expired nearly all talking machines on the market today employ the Berliner process of manufacture.

TRIBUTE PAID IN MARBLE

But not long ago Edison accepted the tribute of a large marble statue representing a Greek figure holding aloft a disc record, and the statue carried the title "Orpheum Discovering the Gramophone Record." The statue was the gift of Edison's employees on Edison's seventy-fifth birthday and following its presentation various pictures were syn-

licated about the country of not only the statue itself but pictures portraying Edison's acceptance of it. And the gift coming as it did from his employees, it is argued that ignorance could not in any way account for such an injustice by innuendo. An observer recently ran onto this picture of "Orpheus Discovering the Gramophone Record" being presented to Edison and about the same time found a published picture of the gold medal presented by the Franklin Institute "To Emile Berliner for his Gramophone." "Can it be," asked this observer, "that the gray-haired intellectuals of the Franklin Institute sometimes get things mixed up a little and do not know to whom they are handing out medals?"

In 1877 Edison invented the tinfoil cylinder phonograph in which he induced vibrations. Before 1886 Chichester Bell, a cousin of Alexander Graham Bell, and Sumner Tainter invented the wax cylinder graphophone and the cutting process, soon afterward adopted by Edison, and in 1887 Emile Berliner invented the gramophone in which the record not only vibrates the needle but also propels it and he got broad patents for this. Berliner also gave to the world the process of making unlimited numbers of exact copies from one master record.

BECOMES MODERN DICTAPHONE

The graphophone aspired to be indispensable in business and at the time of its invention it was believed that in offices it would eventually take the place of correspondence by letter—that business men would dictate to a cylinder and mail this direct. It has become our modern dictaphone.

Now as to the induction coil or transformer:

In telephony the continuous current transformer is one of the most important factors. It is used for the purpose of "boosting" the current. In radio broadcasting, which is an extension of telephony, it is the transformer which connects the speaking current coming from a microphone with the carrying current which throws it out on the air or ether. Induction coil is a name employed synonymously with transformer.

Berliner, according to the patent office records at Washington, was granted a patent for this application of the continuous current transformer January 15, 1878. The number of the patent is 199,141. It was reissued December 14, 1880.

Edison's various biographers, however, give to Edison the credit for having first introduced the induction coil or transformer into a telephone circuit, but they are unable to give the date when he claims to have gotten a patent for it.

INFORMATION IS SOUGHT

The following letter of inquiry, dated September 24, 1926, found its way to the Edison laboratories at Orange, N. J.:

"Gentlemen: I am trying to prepare a prize essay on 'The History of Radio' for a school contest and I want to make it as complete as possible in the way of dates when patents were got, &c.

"Since the induction coil, as it is used in the telephone circuit, is also so important a factor in radio, will you please tell me the exact date when Mr. Edison got his patent for the induction coil appliance.

"I have read the Boy's life of Edison.

"Thank you.

"Yours truly,

"JACK MARTIN.

"Edison Laboratories,
"West Orange, N. J."

To this a reply dealing with other inventions of Mr. Edison's was received, but nothing to the effect that Mr. Edison either invented or patented the telephone induction coil. The letter was signed by William H. Meadowcroft, assistant to Mr. Edison.

On October 14, 1926, another inquiry was sent as follows:

"Dear Mr. Meadowcroft—Thank you for the paper which I am returning and for your letter. My essay on 'The History of Radio' won second prize and now I am going to try to fix it up and win first prize of \$50 in a magazine contest.

"If you kept my letter of September 24 (I think that was the date), you see it was the induction coil I asked about and not a transmitter. I saw in

two books on the life of Edison where he invented the induction coil appliance to the telephone circuit but they did not give the date when he got the patents and it is the date I want because I can't make my story complete without it. I hope I am not putting you to too much trouble. Will you please send me this information. I inclose stamp.

"Yours truly,

"JACK MARTIN."

ANSWER SENT TO INQUIRER

To this the following answer was received:

"Dear Friend—I have just received your letter of October 14, and thank you for returning the paper which I loaned you for use in preparing your essay. I am glad to learn that you won second prize, and hope that you will be successful in winning the first prize in the magazine contest.

"Mr. Edison's contribution to the telephone art consisted of a carbon transmitter which embodied the valuable principles of varying the resistance of the transmitting circuit with changes in the pressure, as well as the vital practice of using the induction coil as a means of increasing the effective length of the talking circuit. Mr. Edison's principal patent on this subject was applied for on April 27, 1877, and by reason of various proceedings in the patent office, the patent itself was not issued until May 3, 1892. The number of the patent is 474,230.

"I trust this will give you the information you desire. Yours very truly,

"WILLIAM H. MEADOWCROFT,

"Assistant to Mr. Edison."

When patent No. 474,230 referred to in the above letter was looked up it was found to contain no reference to an induction coil.

And now as to the question of the microphone:

According to all the records, on April 27, 1877, just thirteen days after Berliner described the microphone in a patent document called a caveat, Edison filed a patent application for another kind of transmitter. The principle of Berliner's microphone was the principle of a loose contact between two or more

electrodes—the loose contact being up to that time a daring innovation in electromagnetics.

EFFECT SOUGHT BY DIAPHRAGM

The Edison transmitter attempted to get the same effect by means of a diaphragm leaning against a disc about the size of the diaphragm on which plumbago had been rubbed. His idea was that every vibration would change the area surface. According to history, the apparatus barely worked, if at all, and a year later Edison invented another form, the so-called compressed lamplack button transmitter which worked by variation in the internal compression of the lamplack button.

Subsequently the Bell Telephone Co., which later controlled both the Berliner and Edison telephone inventions, arranged that Berliner receive the broad patent for the microphone and Edison a subsidiary patent for the use of carbon, although he never has used carbon in microphone fashion.

When the Berliner microphone patent was issued November 18, 1891, among the many editorials published, we cite two:

From the Boston *Globe*, November 18, 1891:

"The Berliner patent, issued this morning from the patent office at Washington, is next to the original Bell patent, the most important patent in the telephone field ever issued. It covers every known form of battery transmitter, and underlies the Blake transmitter, the mechanical device in use in the ordinary box transmitter, and the Hunning transmitter, the mechanical device behind the mouthpiece of the ordinary 'long-distance' transmitter. The Blake transmitter uses two single points of variable contact in the transmission of speech. The 'long-distance' transmitter uses a multiplicity of carbon points of variable contact, but the Berliner patent just issued covers the principle of any variable contact used in the transmission of the sounds of the human voice. All forms of the microphone, of carbon, or any other contact in use for magnifying sound, the 'hear-a-fly-walk' device, an amusing illustration of the wonderful powers of the

microphone which entertained many people about ten years ago—all these and all succeeding mechanical devices, built upon the variable contact principle, now come under the Berliner patent, which bears date today, and can be protected from infringement for the next seventeen years. * * * No known device can be practically used in the telephone exchange system, or in the transmission of speech over long distances except by the Berliner principle of a variable point of contact."

MADE PROFOUND SENSATION

The *Electrical World*, of November 18, 1891, made the following statement:

"Rarely has a patent on any subject whatever caused so profound a sensation as has the granting to Emile Berliner, on November 17, of what on its face appeared to be a broad claim on the microphone transmitter now used well nigh universally wherever the telephone exists. Electrical circles were less surprised than the general public, but a feeling akin to consternation has pervaded the atmosphere during the past week. It is indeed an extraordinary patent, no less on account of the sweeping character of some of its claims than by reason of its remarkable history in the patent office. For an application to remain for one cause or another locked up in the patent office for 'fourteen and a half years before its issue, is almost unique.'"

Mr. Wile, in the Berliner biography quotes further from the press dispatches of November 18, 1891, as follows. From the *Chicago Tribune*:

"A curious computation was made by experts about the patent office today as to the value of the Berliner patent to the Bell Co. The capital stock of that company being \$15,000,000 and the maximum rise in the stock thirty points, it

follows that the value to the Berliner microphone patent, as determined by stock quotations, is \$5,000,000. On this basis, by computation, the patent added one-third to the value of the Bell Telephone's capital stock."

Another press dispatch of the same date commented as follows:

"We think it safe to say, though we do not know that any of the Bell Telephone directors or officials will agree with the statement, that this Berliner patent is of more commercial value than the original Bell telephone patent."

MICROPHONE CALLED EDISON INVENTION

And yet in a broadcast speech made not long ago by William H. Meadowcroft, Mr. Edison's secretary and assistant, and which was later published in a supplement to the *Courier*, January 29, 1926, he said, speaking of what Edison had done in behalf of radio:

"The other item that I have referred to in connection with radio is the microphone. It is well known that this is wholly and entirely Mr. Edison's invention. It is absolutely fundamental and essential, and at the present time radio broadcasting would be impossible without it."

And Mr. Bryan, in the Edison biography, says:

"Then Edison introduced an induction coil. * * * Thus it will be seen that Edison made two radical changes" (referring to the microphone and induction coil). "Almost at once these improvements of Edison's liberated the whole art of telephony."

It might be suggested that Mr. Wile, the writer of the Berliner biography, and Mr. Bryan, the writer of the latest Edison biography, fight the controversy out in their own way.—*Clara Louise Leslie, in The Washington Post.*

AMERICA—THE SPHINX

History makes no reference to the discovery of the continents of Europe, Asia and of Africa, for the simple reason that these continents were known to exist and had been fairly well explored long before history, even in its most primitive, traditional form, was ever thought of. The first discovery of a continent recorded by history was that of the great western continent by Christophoro Colombo in 1492. Strange to relate, the new continent was not named after its discoverer, but after Amerigo Vespucci, an adventurous merchant of Florence, who visited the new continent ten or more years after its discovery, wrote a somewhat fantastic and bombastic account of his voyage and had it published in 1507. The publisher, acting as press agent for the writer, made the claim that not Columbus, but Vespucci had discovered the new continent and suggested that it be named Ameriga, or America, in his honor. As in many other instances since then, the persuasive ability of the press agent won out and the new continent was named America.

The next discovery of a continent of which history took cognizance, was that of Australia in the early part of the sixteenth century. There were many explorers who had a share in the discovery and it may have been owing to the fact that it was by no means certain who the actual discoverer was, that the new continent was named Australia, meaning Southland. Since then only one other continent has been discovered, the Antarctic, which, handicapped by climatic disadvantages, is not likely to attract more than a mild scientific interest.

When history states that America was discovered by Christopher Columbus, the word *discovered* is really to be taken in a relative sense, because the western continent had, undoubtedly, been discovered many times before Columbus. It is beyond reasonable doubt, for instance, that five or more centuries before Columbus, Icelandic and probably other bold Scandinavian sea rovers landed in Greenland and at several

points of the Atlantic coast of North America and even founded colonies. There is also strong reason to believe, that neither the American Indians and the Eskimo tribes of North America, nor the highly civilized races in Mexico, Central and South America, which were practically exterminated by the gold-thirsty, brutal and fanatical Spanish invaders, had originated on the American continent. Whence they came, when they first reached the continent, and whether they found any of the original natives, if there were any, upon reaching the new continent, these are questions that cannot be answered as yet and some of them may never be answered. America—the Sphinx, is guarding the secret of her riddles only too well.

The difficulty of finding answers to riddles does not deter the human mind from persistent efforts in searching for the answers, it rather stimulates such efforts. The astonishing popularity of cross-word puzzles, in spite of their trivial and often stupid character, bears witness to that fact. So, in a much higher and more serious sense, does the wonderful pertinacity of the human mind in searching for the solutions of scientific problems that seemed at first, and in many cases still seem, impossible to find.

The origin of the American Indians is one of these problems. For several centuries it has occupied the minds of scores of great thinkers, explorers and scientists, but only recently discoveries have been made that hold out the promise of eventually leading to a more or less definite solution of the problem.

These discoveries are the result of ten years of study and exploration by a group of researchers and scientists co-operating under the auspices of the Smithsonian Institution. In a statement given out for publication by Prof. B. W. Krieger, curator on the Smithsonian staff, the findings of the research work were briefly presented. The main points may be summarized as follows:

The ancestors of the American In-

dians, including all stocks inhabiting North, Central and South America, were of Asiatic origin and probably derived from some hardy tribes in Tibet. About ten thousand years ago, some of these adventurous tribesmen, in search of new hunting grounds, started in canoes from some point on the northeastern coast of Siberia and sailed eastward across Bering Strait to an island, forty miles from the coast of Asia, and thence to the coast of America, landing at some point in what is now known as Alaska.

Other, similar expeditions, by members of the same tribes followed from time to time and gradually the new arrivals, in true nomadic manner migrated southward and eastward, eventually reaching Central and even South America. Those who migrated to the plains of what is now the central section of the United States, depended upon earth-works for their homes and temples and became mound-builders, that mysterious race that was supposed to have antedated the Indians.

The ancestors of the Indians undoubtedly came from northeastern Asia. This theory is strongly supported by the fact that the folklore of the Indians is practically duplicated by that of the Chukchi and Tungus tribes of northeastern Asia. The Eskimos also came from northern Asia, but probably much later.

The hair texture, facial type, teeth and limb measurements of the Indians in all parts of the American continent are practically the same and are identical with those of the tribes in northeastern Asia.

The comparatively high cultural development of the Indians of Mexico and of the Inca Indians of Peru may be explained by climatic conditions and environment which caused them to abandon nomadic life and depend on agriculture for their means of living. This change eventually led to the development of other arts and of a higher degree of culture.

The North American Indians, plentifully supplied with game, including countless herds of bisons, had no incentive to become settlers and continued their nomadic life.

The findings of the Smithsonian research expedition given above, strongly confirm the theories of Dr. Ales Hrdlicka as expressed in his article on "The American Indian" in Vol. II. of the *Annualog*, pages 60-66, but they do not answer the question: Were the Indians coming from northeastern Asia the first inhabitants of the American continent, and, if not, who were the original occupants? Another riddle of the Sphinx.

What appears to be a conclusive answer to the first part of the riddle, came quite recently from an entirely unexpected quarter, not from anthropology, but from geology. It was given in an article written for the July issue of *Natural History* (published by the American Museum of Natural History) by Dr. J. D. Figgins, director of the Colorado Museum of Natural History, and reviewing the work and findings of an expedition sent out by the Colorado Museum some time ago.

According to statements contained in Dr. Figgins' account, the expedition unearthed in the course of its geological explorations three highly important specimens which prove beyond reasonable doubt, that some prehistoric human race inhabited the American continent during the time of the upper Pleistocene, formerly estimated to have been about 100,000 years ago, but now believed to date back approximately 1,000,000 years. The present estimate is based upon time determinations by the uranium-lead-helium method, developed in the course of the study of disintegration of radio-active substances.

In Texas the fossil remains of a bison, containing the stone head of the arrow that presumably killed the animal, were found. In Oklahoma the skeletons of another bison and of a camel were unearthed, together with the arrowheads which had inflicted their death wounds. In the case of the Oklahoma bison the arrowhead was found securely lodged in the matrix of the fossil, close to the ribs.

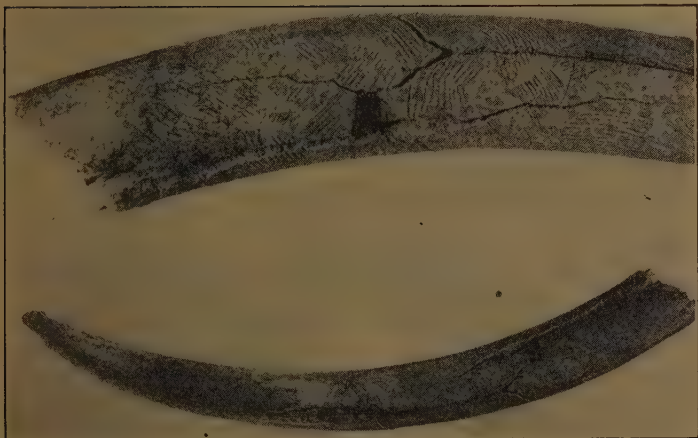
The two bisons belonged to a species much older than any heretofore found and are believed to date from the time of the upper Pleistocene. The same holds good in the case of the camel,

which may have been an ancestor of the llama.

Although no direct evidence of Pleistocene man has been found, the finding of the man-made arrowheads, directly associated with the fossil remains of animals of the Pleistocene, is considered as proof that man must have inhabited

this continent during that remote period.

Now, ask me another! Was Pleistocene man indigenous of the American continent and, if not, whence did he come? Furthermore, if all these discoveries are correctly interpreted, where does Christopher Columbus come in?—*E. Welleck.*



RECENTLY IN CZECHOSLOVAKIA, ARCHEOLOGISTS DISCOVERED CARVED TUSKS
TWENTY THOUSAND YEARS OLD

FOSSIL BONES OF EARLY MAN

EARLIER FORMS ARE MORE PRIMITIVE

There is no doubt that, as compared with the vast number of flint implements found in ancient deposits throughout the world, the discoveries of the bones of the human beings who made these implements are exceedingly rare.

It is, of course, only to be expected that his flint implements would be numerous because, in the first place, every prehistoric man must have made a great many in his lifetime—as do primitive people of the present day—and secondly, these specimens are practically indestructible, and so have survived the drastic vicissitudes of the past.

On the other hand, the comparative scarcity of ancient human bones is not a very surprising fact, since the population of early prehistoric times could not have been by any means large. Further, it is probable that when an individual died, his body was left out in the open to decay, or to be eaten by carnivorous animals. The fossil bones of man that are found in ancient gravel beds and other water-laid deposits, are almost certainly those of people who were drowned, or whose bodies, left lying in the open, were swept away by floods and buried in the gravel and other deposits which were then being formed. Although the precious remains of man are therefore rare, yet enough of them have been found to enable us to form a clear idea of the type of people who inhabited this earth in remote times.

A SKULL BOTH HUMAN AND APE-LIKE

There cannot be any question that as we go back into the past, the type of man becomes more and more primitive, and shows an ever-increasing similarity to those of the higher apes. Although the existence of man at any given period can be proved with certainty by the finding of his flint implements in the deposits of that period, yet the discovery of actual human bones is always regarded as a crowning triumph of research in prehistoric archaeology, for it sets the seal of certainty upon the

previous finds of his flint implements. In this article I propose to describe to you some of the more important discoveries of human fossil bones that have been made, and to show their great antiquity.

About thirty-five years ago, a remarkable discovery was made in Java by Professor Dubois, who had been sent out by the Dutch Government to explore certain deposits in that island, which were known to be very rich in the fossil bones of animals. Fortunately, these researches resulted in the discovery of the upper portion of a skull, the thigh bone, and two teeth of a creature that evidently possessed both human and ape-like characteristics. The discoverer of these remains gave to them the name of *Pithecanthropus erectus*, or the "erect walking man-ape." There can be no doubt that this title is correct. The skull cap shows marked ape-like features—a great projecting, bony ridge over the eye-sockets and an almost non-existent "forehead"—while the inside capacity of the skull has been shown to be intermediate between the highest apes and the lowest type of man. Although the skull cap exhibits these remarkable characteristics, the thigh-bone and teeth, which must be referred to the same individual, approximate very closely to those of modern man.

Thus we see that in this Javan discovery there is placed before us a creature possessing both ape-like and human resemblances. The exact geological age of this fossil has been in dispute, as is often the case, with the remains of ancient man, but it belongs either to the close of the Tertiary, or "third" geological period, or to the beginning of the Quaternary, or "fourth" period; and it is quite likely not far from one-half million years old.

Another very important find—that of a human jaw-bone in fossilized condition—was made in 1907 at Mauer, near Heidelberg, in Germany, at a depth of about ninety feet from the present surface of the ground. The geological

age of this specimen is well known. Judging from the nature of the animal remains found with it, it is clearly of the same period as that of the Cromer Forest Bed of Norfolk, from which I have obtained a large number of flints flaked by human hands.

APE-LIKE JAW, HUMAN TEETH

The Heidelberg, or Mauer, jaw-bone is a most impressive relic of early man. Not only is its antiquity profound, but its massive size and brutal appearance at once rivet the attention of anyone examining it. The specimen shows no sign of a chin, and the ascending rami (those portions of the jaw which branch upwards from behind the rearmost molar teeth) are of extraordinary width and strength. It is obvious that the being who possessed a jaw-bone of this character must have been almost of gorilla-like proportions. In fact the jaw-bone itself, if the teeth had been missing, would have almost certainly been regarded as that of an ape. But nearly all the teeth are present, and these are of a definitely human type.

Thus, in the Heidelberg jaw-bone we see again a combination of human and ape-like characters.

We turn to a discovery made at Piltown in Sussex, England, some years ago, by the late Mr. Charles Dawson of Lewes. When visiting a shallow pit where gravel was being raised, he obtained from a workman some portions of a very thick and fossilized human skull. This important find induced him to conduct diggings in the same gravel pit, and eventually half of a lower jaw-bone and a large human canine tooth were discovered. The gravel in which these remains occurred is not far from the valley of the River Ouse in Sussex, and is evidently a very ancient deposit. Unfortunately, the gravel is not of great depth, nor is it covered by any other bed which would enable us to "date" it geologically. Thus, the exact age of the Piltown deposit, though unquestionably very ancient, is not known; but the flint implements found in the same deposit of gravel are of very early types such as we know occur in beds of the Late Tertiary and Early Quaternary periods in East Anglia.

THE ORIGINAL CAVE MAN

The skull and jaw-bone, which have been described by Dr. Smith Woodward, and by Sir Arthur Keith, show us once more an individual with both human and ape-like characteristics. The skull is of definitely human form. It shows no trace of the projecting ridge above the eye-sockets, such as is so prominent a feature in some early types of man. The bones of this skull are very thick, but otherwise in its general



Courtesy of the "Illustrated London News"

THIGH BONES

Modern Man—Java Ape-Man—Gibbon

outline there is nothing very ape-like about it.

But when we turn to the jaw-bone we see a very different picture, for it possesses many ape-like characters. There is the usual absence of a chin, and the whole aspect of the specimen is very primitive. The most outstanding peculiarity of it is the canine teeth, which stick up above the level of the others, in the same way in which the ape's canines project. Never before has a human being been known with a

definitely human skull, and with jaws showing canine teeth of this kind. Thus, the Piltdown discovery is of great importance and interest to all those who are interested in man's ancestry.

It is possible that those fossil remains which I have described, namely, those of Java, Heidelberg, and Piltdown, lived during the warm climatic phase inter-

are known by the name "Neanderthal," because the first skull of this race was found in a cave in the valley of the Neander River in Germany. A very great deal is known of these early people because several nearly complete skeletons of them have been found. These finds clearly represent ceremonial burials—the oldest intentional interments as yet discovered.

The Neanderthal race used very characteristic and well-flaked flint implements, and was associated with a large number of cold-loving animals whose remains have been found in the deposits of the period during which this race lived in Europe.

The skulls of these people were very long and thick, and had a great bony ridge extending across the eye-sockets. The Neanderthal people had massive jaws and teeth and short, thick limb bones. An examination of the leg bones of this race shows that they probably walked with a slouching gait, and from the position of the *foramen magnum* (the aperture at the base of the skull through which the spinal cord passes to the brain), it is concluded, that they carried their heads projecting forward.

So far as we know, the Neanderthal people eventually became extinct; but their bones tell human anatomists a wonderful story of one of the ancient types of man that inhabited Europe in remote prehistoric times.

Before the Neanderthal race entirely disappeared, a new and much higher type of prehistoric hunters had entered western Europe, bringing with them a hitherto unknown culture. These newcomers were remarkable people, for not only were they quite "modern" in their bodily form but they were artists of no mean ability—as the drawings, sculptures, and engravings of animals they left behind them in their old camping places, so vividly show.

The first discovery of skeletons of this race was made in the rock shelter of Cro-Magnon in France, where they had been buried. It revealed a type of individual of commanding height, long-headed, and with jaws and limb bones comparable to those of the highest races existing today. Indeed, my friend, Sir Arthur Keith, has likened them to



AN EARLY PALEOLITHIC FLINT

vening between the first and second glacial phases and are possibly 500,000 years old.

We must now pass on to a later epoch, when the third glacial episode or ice invasion was commencing and western Europe was peopled by a strange race whose remains have been found in caves and rock shelters over a large area of country. These human beings

the Sikhs of India, while others, because of their artistic powers, have called them "the Paleolithic Greeks."

NEANDERTHAL MAN NOT OUR ANCESTOR

The origin of the Cro-Magnon people, as they are called, is somewhat obscure; but it is clear that they could not have developed from the primitive Neanderthals. Therefore, their ancestors must be looked for in pre-Neanderthal times, and it is probable that the well known Galley Hill, St. Denis, and other discoveries of human bones of modern type in very ancient deposits represent these ancestors. There would thus seem to be no doubt as to the great antiquity of the modern type of man of which the Cro-Magnon people of about 30,000 years ago were such splendid physical examples.

The fact must be emphasized that the

Neanderthal race cannot be regarded as the ancestors of modern man (*Homo sapiens*). It would appear that, possibly, the cold climate conditions obtaining in Europe in middle Paleolithic times favored the sturdy Neanderthals, and enabled them for a considerable period to dominate western Europe. But, both in their physical structure and in their flint implements, they represent a very early and primitive type of mankind.

In this short survey I have mentioned merely a few of the discoveries that have been made of ancient human bones; but even this evidence is, I think, sufficient to carry conviction as to the great antiquity of man, and that, as we delve into the very remote past, we find human types becoming more and more primitive, approximating in their bodily form to that of the higher apes.—*J. Reid Moir.*

BIBLE STATISTICS

The following statistics are those given in the Introduction to the Critical Study and Knowledge of the Bible, by Thos. Hartwell Horne, D.D., first published in 1818. They apply to the English Authorized Version.

	O. T.	N. T.	Total
Books.....	39	27	66
Chapters....	929	260	1,189
Verses.....	23,214	7,959	31,173
Words.....	593,493	181,253	774,746
Letters....	2,728,100	838,380	3,566,480

Apocrypha: Books, 14; chapters, 183; verses, 6,031; words, 125,185; letters, 1,063,876.

	O. T.	N. T.
Middle Book	Proverbs	2 Thess.
Middle Chapter..	Job xxix	Rom. iii and iv

Middle Verse..	2 Chron. xx, 17-18	Acts xvii, 17-18
Shortest Verse..	1 Chron. i, 25	John xi, 35
Shortest Chapter..	Psalm cxvii	
Longest Chapter..	Psalm cxix	
Ezra vii, 21, contains all the letters of the alphabet except j.		
2 Kings xix, and Isaiah xxxvii are exactly alike.		

The last two verses of 2 Chron. and the opening verses of Ezra are alike.

Ezra ii and Nehemiah vii are alike. The word *and* occurs in the O. T. 35,543 times, and in the N. T. 10,384 times.

The word *Jehovah* occurs 6,855 times and the word *Lord* 1,855 times.

About 30 books are mentioned in the Bible, but not included in the canon.

BIRTHPLACE OF MANKIND

EVIDENCE OF THE FLINTS

One of the most interesting pursuits is the systematic study of ancient man's workmanship in stone, for these studies throw direct light on the gradual evolution of his intelligence. Starting with the present time and delving deeper and deeper into antiquity we first pass the comparatively recent New Stone Age with its generally superb skill. Then the Old Stone Age is traversed, several hundred thousands of year in length and containing within itself a marked evolution in workmanship. But even before that, as we push back towards the dimmest horizons, we reach the stage where man's implements consisted simply of stones picked up because they were already fairly well shaped by nature for his purposes, and improved by his dawning intelligence. These are the *coliths* and it is chiefly of them that Mr. Moir, discoverer of thousands of them, here writes so entertainingly. More than anyone else, Mr. Moir was instrumental in establishing that the *coliths* were partly man-made instead of altogether accidental products, as was formerly claimed—and is still claimed by a few "die-hards."

EOLITHS 1,000,000 YEARS OLD

Although all those who have made a study of the matter are convinced that man has, during an immense period of time, been slowly evolved from a very primitive ape-like condition to his present high development, yet the exact part of the world where the earlier stages of this momentous process were gone through has not been definitely ascertained. The solution of this problem which, of course, in no way invalidates the truth of human evolution, is of great interest and importance to science and to everyone.

It may be said at the outset that there are in existence two opposing schools of thought upon this question—one favoring the idea that to Asia must be accorded the honor of being the birthplace of mankind, while the other regards

western Europe as having had that distinction.

Now, it will be realized that in attempting to decide where man originated, the only facts that can carry real weight and influence a decision, are discoveries in ancient deposits of *actual remains of man*—either in the form of portions of his skeleton, or as undoubted works of his hands—such as stone implements. When the matter is looked at from this standpoint, there cannot be any doubt that so far as discoveries of prehistoric relics are concerned, Europe has, in every way, most in its favor. It is, however, necessary to recognize that this part of the world has been explored extensively by archaeologists for many years past, whereas the investigation of Asia is only just beginning. But we must take the facts as we find them, and these demonstrate beyond question, that western Europe is infinitely richer in remains of early man than is Asia.

It has been pointed out by Professor Henry Fairfield Osborn that during the period of archaeological research intervening between 1823 and 1925, the fossil bones of no less than 116 human beings—referable to the Old Stone Age, or even earlier—have been found in Europe, while the number of flint implements of different ages discovered in this area is literally beyond computation. These relics of remote humanity range from the earliest to the latest paleolithic times, but no one supposes that the first-made implements of this period represent man's initial attempts to shape stone by flaking, and so the presence of even the oldest paleolithic specimens in any given locality does not by any means prove conclusively that man originated there.

Fortunately, there has been found in southeastern England and in France evidence of the former existence of man at periods long pre-dating that of the earliest paleoliths, and it is to the earliest of these pre-paleolithic implements

that I wish to draw particular attention. These specimens are made from pieces of flint naturally produced in tabular shape, and they exhibit steep flaking along one or another of their edges, which has caused the flints to assume various implemental forms.

I have made a very close study of these flaked flints and have carried out numerous experiments in flint fracture in order to see whether such specimens can be produced by natural, non-human means. These investigations have convinced me that the type of flaking ex-



J. REID MOIR

hibited by these eoliths, and their very definite types, again and again repeated, can only be accounted for by regarding these specimens as having been shaped by some intelligent being. Thus, some of the eolithic flints are pointed (Figures A, D and E) and could have been used for boring holes in various materials. Others represent *racloirs*, or side-scrapers for dressing skins and for cutting purposes (Figure B); while the hollow-scraper (Figures C and F) is a common type and would have been very useful in shaping wood and bone.

The eoliths, as they are called, are represented by only two or three types and their forms of flaking are of an extreme simplicity, while their color and condition are archaic to a degree. It is, in fact, not possible to conceive of any artificially flaked flint more simple and rudimentary, and the conclusion is inevitable that in these specimens we see the kind of artifact that would be made by a creature just emerging from a simian condition.

But it must, however, be realized that before such a creature became intelligent enough definitely to flake a stone to a desired form, there no doubt passed a very prolonged period during which proto-man was using any stone he could find, with or without a natural cutting edge, for various aggressive and also peaceful purposes.

Thus, an ordinary flint with a rounded surface would have been very effective in breaking open bones or shell-fish for their edible contents, or for giving the knockout blow to a human or animal enemy. Such specimens would probably be used once and then thrown away, and little or no signs of the use to which they were put would now be visible. Further, such signs would be indistinguishable from others produced by purely natural means, and thus would fail to provide archaeologists with reliable evidence in favor of the high antiquity of man. Even in the case of some flints flaked in a primitive manner, it is not always by any means easy to say with certainty whether they have been fractured intentionally or by the unguided forces of nature, for flints can be fractured, for example, on a sea-beach, by being hurled against one another by the waves. They can be flaked by the pressure of great masses of strata in movement, and lastly, by drastic alternates of heat and cold.

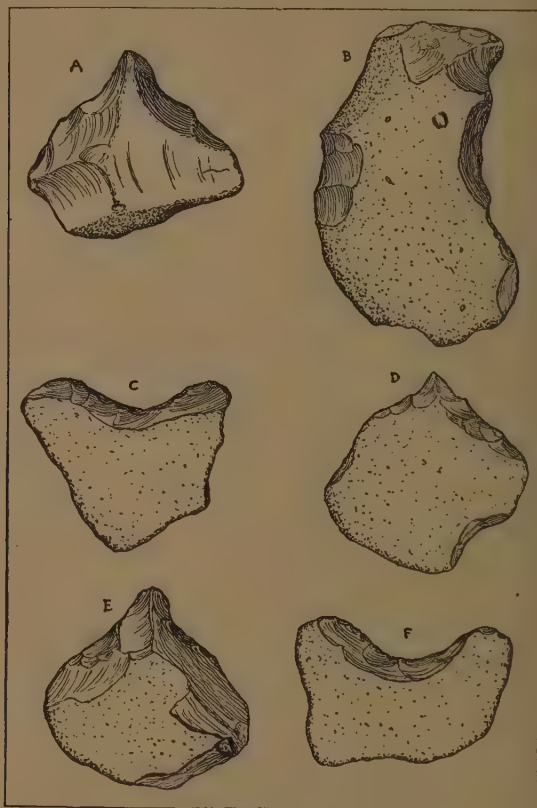
APING EOLITHIC MAN

For the archaeologist who wishes to stand upon firm ground, it is vitally necessary to become familiar with the characteristics of the various forms of natural flaking, and by means of experiment to gain some idea of the limitations of nature in this matter. The

subject of the fracture of flint seems, no doubt, very obtruse and "dry" to the ordinary non-scientific person, but, in reality, it is of consuming interest and wonder and unquestioned importance.

Some years ago, I carried out a large

as would be expected, and it finally differentiates the eoliths from the results of haphazard natural forces. The same forms, carefully flaked and again and again repeated; the direction of the flake; removing blows, and the charac-



EOLITHS OF VAST ANTIQUITY

series of experiments in flint-flaking and these convinced me that while nature, by chance, occasionally does some wonderful things in shaping a stone, yet, an examination of her handiwork fails to reveal any signs of this shaping being done for any *purposeful* end. This is

characteristics of the flake-scars—all speak eloquently of the artificial origin of the flaking upon these very primitive stones.

When we proceed to enquire into the geological age of the eoliths, it becomes clear that they must be referred to a very remote period of the earth's his-

tory. In Kent, England, where many of these implements have been found in a thin deposit of gravel—about 700 feet above sea-level, upon the top of the North and the South Downs—it is plainly evident that the water which laid down this gravel in which the flints occur, flowed from a high dome of chalk that, at one time existed over the whole of the weald of Kent. Since that epoch, enormous denudation has taken

But even so, vast geological and climatic changes have occurred in East Anglia since the bone bed and the ancient gravels previously mentioned were formed, and it is certain that the eoliths are much older than these formations. The measure of their real antiquity may perhaps be gaged by a discovery made at Puy Courney, central France, where definite colithic implements are found in a gravel associated with the bones of



WHERE EOLITHS WERE DISCOVERED

place and there cannot be any doubt that the time involved in this process has been immense.

In Suffolk, specimens in every way comparable with those found in Kent, have been recovered by me from the bone bed beneath the Red Crag (a marine deposit laid down in Early Quaternary times). Also other specimens have been found in certain very ancient gravel beds in the same county. The specimens from both these horizons are, however, rolled by water and had evidently a long history before arriving in the deposit where they are now found.

Upper Miocene mammals and overlain by a flow of lava that occurred at the end of the Miocene Epoch.

EVIDENCE POINTS TO EUROPE

There is, thus, abundant evidence that the eoliths are exceedingly primitive in form, archaic in appearance, and of a great geological antiquity. In fact, in my opinion they provide us with the implements made by the Dawn Men of at least 1,000,000 years ago, and although up to the present no human bones of colithic age have been found in western Europe, it is highly probable that the

simian type of individual (see page 93) discovered at Trinil, in Java, by Dubois, represents the kind of emergent creature who flaked these rudimentary and enormously ancient flints.

When it is realized that the eoliths have been found in quantity in England and in France, and that from eolithic times onward there has been discovered in these countries practically an unbroken series of artifacts, representative of every stage of man's prehistoric past, it is inevitable that those who are familiar with these facts should regard it as quite possible that some part of west-

ern Europe was the birthplace of mankind. In the Miocene Epoch to which the eoliths must, it would seem, be referred, this part of the world was enjoying a tropical climate, and would have provided the necessary conditions favorable for the successful inauguration of human evolution.

Whatever discoveries may in the future be made in Asia, it is difficult to imagine them giving us a more complete story of the history of man than has been revealed by archaeologists in western Europe and in England.—*J. Reid Moir.*

THE REAL TORNADO

The commonly accepted definition of a tornado, often found even in dictionaries, is erroneous, according to the Weather Bureau of the United States Department of Agriculture. The "funnel-shaped cloud like a waterspout, sand column, or dust whirl" is not the tornado itself, but a phenomenon that occurs with it, a product of the violent and destructive winds that constitute the tornado. In meteorological terms a "tornado" is a small, violent, rotating wind-storm, sometimes confined to an area of a thousand feet or less.

A "cyclone," as meteorologists understand it, is a system of winds accompanying an extensive region of low barometric pressure. It may cover an area of a thousand miles or more, and

is usually characterized by clouds and precipitation. A "hurricane" is a cyclone which usually originates in the warm waters of the South Atlantic or Caribbean Sea, and consists of violent destructive winds that damage property and endanger life. This same type of storm is called a typhoon when it occurs in the vicinity of the China Sea and the Philippines. The probable direction of a hurricane can be predicted from observations, and the speed of its progress is reckoned from its measured wind velocity. The Weather Bureau sends out by radio and telegraph warnings of approaching hurricanes, so that ships at sea and persons at all points in their paths may take steps to protect themselves.—*U. S. Dept. of Agriculture.*

RECENT PROGRESS IN COSMOLOGY

Cosmology, the Science of the Universe, is so vast of scope, so complicated, and so difficult to attain by the relatively primitive instruments and methods of observation at our command, that the total of our present knowledge, insignificant compared with the vastness of the subject, reflects great credit upon the intelligence and ingenuity of the human race.

The evolution of Cosmology, like that of every other science, proceeded logically, step by step. The first step was observation, the second, interpretation, the third, correlation, the fourth, systematization. We may safely assume that the sun, moon and stars were observed by man even during the most primitive stage of his development. He may even have attempted the second step, interpretation, but undoubtedly many thousands of years elapsed, before he succeeded in interpreting correctly what he had observed. The myths and legends of the ancient races with which we are acquainted, bear witness to the fact that even at the beginning of historical time the human race was far from a correct interpretation of the cosmic bodies that had been observed for many thousand years.

The crude and childishly fantastic accounts of the creation of the Universe, of the laws governing its functions, the forces compelling and determining the motion and orbits, et cetera, of stars and planets, which, invariably formed the foundation of religious cults, are even at the present time accepted as inviolable truth by the ignorant masses throughout the world, while millions of people who are on a higher level of intelligence, compromise by pronouncing these accounts mere allegories conveying the truth in fanciful disguise.

When primitive man first became sufficiently interested in the why and wherefore of the natural phenomena which he observed, to make an attempt to explain them by reasoning, it was only natural for him to come to the conclusion that the earth on which he lived stood still, while the sun and other heavenly bodies circled around it. To

him, the Earth was the center of the universe, specially created for him and placed, where he believed it to be, for his exclusive benefit.

This explanation seemed so natural and was so flattering to the feeling of superiority of man, that it was accepted as true for many thousand years. In the slow course of time man's intellect developed step by step, he devised means and methods of making more precise observations, which conflicted with the conceptions derived at from previous observations, made by the most primitive means and methods. Doubts began to arise in the minds of some of the more advanced students and, using more exact observations as the basis of their reasoning, they arrived at results diametrically opposed to archaic conceptions. According to historical records, it was Aristarchus, a learned man of Samos, who, about 260 years before Christ expressed the conviction that the earth rotated and circled around the sun in a definite orbit, not the sun around the earth. And yet, 1892 years later, Galileo saved himself from being executed for expressing the same conviction, which was considered sacrilegious, only by recanting his statements, however with a mental reservation.

With the invention of improved instruments of observation and the employment of better, more scientific methods of interpreting and collating the observed facts, the various branches of cosmology developed with increasing rapidity and, particularly during the last hundred years, tremendous progress has been made.

At no time in the history of Cosmology has progress been more rapid than in the past two or three years. Many problems, heretofore inaccessible to research because of the lack of instruments and methods of conclusive investigation, have been solved or, at least, been brought much nearer to their final solution than had been thought possible heretofore.

The question, whether cosmic space is infinite or not, no longer occupies the

minds of modern scientists and philosophers. They have come to the conclusion that both alternatives are unthinkable and, at all events, beyond the possible range of verification. But the problem of determining the distances between the earth and the most remote star systems visible to us, has lost none of its interest and quite recently some highly remarkable investigations have led to equally astonishing results.

One of the most interesting accomplishments in that direction was the analysis recently completed, of the star system in Sagittarius, which was discovered by Prof. Barnard in 1884 and is listed as N. G. C. 6822 in Draper's "New General Catalogue". The analysis was based on a series of photographs of that distant nebula, taken with the aid of the 100-inch reflector of Mount Wilson Observatory. An account of the work and a statement of the results obtained was published in "The Scientific American" of April, 1926. Details of the methods employed and of the data deduced may be found in the article referred to.

Briefly summarized, the following salient facts were deduced:

According to actual count, the star system contains about 750 stars of or exceeding magnitude 19.4 and uncounted thousands of lesser magnitude. Among the larger stars included in the count, fifteen variables were observed, eleven of which showed regular periodic changes in their light intensity, similar to that characteristic of the variables of the Cepheid group. The star system is approximately 1,200 parsecs or 3,912 light-years = 23,080,800,000,000 miles long and approximately half as broad. Its distance from the earth averages 700,000 light-years, equal to more than 4,000,000,000,000,000 miles. Although this distance is more than three times that of the most distant star heretofore known, it is believed by astronomers that some of the faintly visible nebulae, far from the plane of the galaxy, are even more distant.

When we speak of physical, astronomical and other cosmological subjects, we often deal with enormous figures, expressing distance, speed of motion, volume, et cetera, in our accustomed

standards of measurement. But, as the horizon of our cosmological knowledge expanded, our standards, sufficient for terrestrial measurements, were soon found to be inadequate to express such distances, speeds, et cetera, as we had to deal with in the study of the cosmos in general. To simplify mathematical terminology in speaking or writing of distant stars, star systems, nebulae, et cetera, new terms were coined. We speak of distances in terms of astronomical units, equal to the distance from the earth to the sun, which is 92,900,000 miles; of parsecs, each equal to 206,265 astronomical units or 3.26 light-years, a light-year being the distance covered by a ray of light in one year, traveling at the rate of 186,324 miles a second.

These terms and figures express distances and speeds mathematically, but the human mind is absolutely incapable of forming a conception of their actual meaning, nor even of imagining them.

When Albert Einstein, some years ago, presented to the scientific world his Theory of Relativity, it created a tremendous sensation and met with violent opposition, partly due to the fact that it was not completely understood. Mathematicians were the first to acquiesce, but physicists, chemists, and astronomers refused for various reasons to accept the theory in its totality. For centuries, the existence of an all-pervading medium, filling all space, the cosmic ether, was considered an essential prerequisite in accounting for various physical and chemical phenomena. To accept the theory of relativity *in toto*, meant to give up the cosmic ether and that, obviously, could not be done without seriously menacing the fundamental structure of the sciences involved.

Some of the opponents of the Theory of Relativity openly demanded that its originator should prove the non-existence of the ether, but Albert Einstein, though himself a physicist, did not accept the challenge, evidently being of the opinion that, if the physicists and others considered the ether a *conditio sine qua non* of their respective sciences, it behooved them to prove its existence. If they could not prove its existence, they could not, logically, combat or reject the Theory of Relativity simply

because it did not recognize the existence of the ether.

Since then a number of noted physicists have undertaken the task of settling the controversy by careful scientific tests that would conclusively prove or disprove the existence of the ether. Optical and electro-magnetic methods were employed, at first with crude, later with greatly improved apparatus, but while some of the investigators obtained, what they interpreted as a confirmation of the ether theory, others arrived at either negative or inconclusive results, and the problem remained unsolved.

Prof. Dayton C. Miller, an American scientist, who had investigated the problem several years ago by optical methods at the Mount Wilson Observatory, but had obtained unsatisfactory results, resumed his investigation in the early part of 1926 at Mount Wilson Observatory, using the reconstructed Michelson interferometer that had been employed in previous investigations. He was favored in his work by unusually good weather conditions and made 34,000 readings by photographic method. Again, Prof. Miller found a periodic displacement of the interference lines, which was clearly systematic and which he attributed to cosmic influences. The displacement seemed to indicate an ether drift of approximately 6.2 miles a second. The correctness of these observations is, however, not accepted by some other scientists, nor are the conclusions which Prof. Miller has drawn from his observations, admitted as justified. Under these circumstances the ether problem does not seem to be nearer to its solution than it was several years ago, and it is quite likely that it will remain an open question for many years to come, if not forever, because of the extreme difficulty of obtaining conclusive proofs that would convince all scientists.

Twenty or twenty-five years ago, the sciences occupied with the study of the earth, its origin, its age, the origin of life on it and the nature and laws of the physical and chemical phenomena and processes, et cetera, had practically reached the point beyond which their investigations could not be extended

excepting in a purely speculative way. It is true, a great deal of work could still be done, but it was principally of a supplemental character, rounding out the totals of human knowledge in various fields of science by filling out gaps.

This condition was completely changed by a number of important discoveries in geology, geophysics, physics and chemistry during the past twenty-five years. These discoveries, particularly that of radio-activity, not only enriched the sciences to which they primarily pertained, but were soon recognized as being of enormous value in clearing up problems in other fields of science, which heretofore had resisted solution.

Two of the great problems, naturally most interesting to man, have ever been the origin and the age of the earth. These two problems pertain logically to the domain of geology, one of the youngest of sciences, but, at the same time, one of the most comprehensive and complicated. By making a careful study of the structure of the lithosphere, as the more or less solid outer shell or crust of the earth is called, the geologists ascertained with a fair degree of accuracy that this planet had passed through a series of changes or geological periods, the sequence and distinguishing characteristics of which were written in the rocks and other mineral strata of which the lithosphere is composed. By a careful study of the accessible strata of rocks and other component parts of which the lithosphere is composed, the geologists were enabled to ascertain their relative positions in the structural sequence, beginning with the pre-geologic era and leading step by step to the most recent part of the youngest, the psychozoic or quaternary era. For the sake of convenience the geologic history of the earth was divided into eras, which, in turn, were subdivided into periods. Names were given to the different eras and periods to avoid confusion and the various major and minor divisions and their given names are recognized by geologists in all countries.

The determination of the length of time of each period and era presented a far more difficult problem and, until quite recently, it seemed that geologists

would have to confine themselves to estimates based on entirely arbitrary guesswork. Quite unexpectedly, the discovery of radio-activity brought to them valuable aid and made it possible for them to calculate the duration of the geologic eras and periods with much greater accuracy than heretofore.

To make it clear what radio-activity has to do with the time-element of geologic periods and eras and with calculating their duration, a brief explanation may be proper.

The foundation for our knowledge of what is now called radio-activity was laid by Henri Antoine Becquerel, a French physicist, who, while experimenting with pitchblend at the beginning of the present century, discovered that the concentrates of that ore sent out radiations of a peculiar character, which became known as Becquerel Rays. Pitchblend is a mineral of highly complicated composition and contains uranium, lead, thorium, niobium, yttrium, lanthanum, helium and oxygen in varying proportions. Pierre Curie and his wife, Mme. Marie Sklodovska Curie, undertook the task of isolating from the concentrate of a considerable quantity of pitchblend ore the substance which emitted the strange rays discovered by Becquerel. Having isolated the uranium and thorium, which both were found to send out radiations, from the concentrate, the investigators discovered to their surprise that the remaining concentrate emitted radiations far more powerful than those sent out by the extracted uranium and thorium. They continued their analytical work, which eventually led, first to the discovery of polonium by Mme. Curie and later to that of radium.

Subsequent investigations of the newly discovered elements established the fact that the elements of the group to which they belong in the periodic system are characterized by great instability. It was found that uranium and thorium, by disintegration, are transformed into other elements: uranium to radium and this, in a descending line, to radium emanation, which, after passing through a number of intermediary stages, forms polonium and finally uranium-lead, differing from ordinary lead only by its

lower atomic weight. By disintegration, thorium, in a similar manner, is changed to mesothorium, radiothorium and finally to thorium-lead, which is chemically identical with both uranium-lead and ordinary lead. During these inter-atomic changes, infinitesimally small particles of substance, and rays are emitted by the changing matter. The most important of these are the alpha rays, consisting of helium atoms, the beta rays, which are composed of electrons, or unit charges of negative electricity, moving with a speed approaching that of light, and gamma rays, which are identical in nature with X-rays.

Many highly interesting and important facts were learned during the intensive study of radio-activity. It was found that the rate of disintegration is not influenced by conditions and cannot be changed by human power. Neither changes of temperature nor of pressure have any effect on the speed of the progress of disintegration. After extensive research it became possible to ascertain the average duration of life of the radio-active elements with a fair degree of accuracy. It was ascertained that the transmutation of 1.4 percent of a given quantity of uranium to lead requires approximately 100,000,000 years, in the case of thorium even 300,000,000.

The knowledge thus obtained made it possible closely to estimate the age of any uranium or thorium mineral and, consequently, of any formation containing such minerals, from the relative proportion between the quantities of uranium or thorium and the lead contained in the minerals. That the lead found together with uranium and thorium is not ordinary lead, but was formed by the disintegration of the elements mentioned, is demonstrated by the fact that it has the atomic weight of 206, while ordinary lead has the atomic weight of 207.2.

By applying the information gained in the study of radio-activity the previous estimates of the age and duration of the geologic eras and periods were subjected to a thorough revision, which showed that all previous estimates had been far too low. It was found that 335,000,000 years must have elapsed since that period of the Paleozoic era in which the coal

beds were formed. Since the time of the middle Cambrian period, in which some of the lowest forms of invertebrates and the first known marine fauna appeared, from 1,100 to 1,350 million years must have elapsed and since the lower pre-Cambrian even 1,600 million years.

The recent discovery, study and interpretation of what is known as "pleochroitic courts" has supplied an additional means of estimating the age of minerals and geologic formations. These microscopic "courts," which have been found in mica, tourmalins, fluorites and other minerals, appear under the petrographic microscope as circular spots with a diameter of 0.066 to 0.080 of a millimeter. They are produced by the effect of the alpha-rays emitted during the disintegration of some trace of a radio-active substance enclosed in the mineral. From the degree of discoloration of the mineral within the "court," the radius of which coincides with the range limit of the alpha-rays, it is possible to estimate the age of the mineral containing the "courts," and hence of the formation in which the mineral is found. By employing this method the conclusion has been reached that since the time of the lower Devonian, which preceded the coal-forming periods, 470 million years must have elapsed. By the same method, the age of the Jurassic and Triassic periods has been estimated at 250 million years, that of the oldest known sedimentary deposits at 1,600 million years.

The recent discovery of well preserved fossil remains of lower animals in pre-Cambrian formations near the Canadian border by the American geologist, Prof. J. D. Walcott, has awakened renewed interest in the question, "When did animal life begin on our planet?" From the fact that Dr. Walcott's pre-Cambrian fossils, the age of which is estimated to be approximately 1,000 million years, showed a clear differentiation of types, it seems obvious that the evolution of these types must have required millions of years, far more than the 1,600 million years that have elapsed since the oldest pre-Cambrian period. In the light of these recent discoveries it is now estimated that the first oceans,

in which life undoubtedly first originated, were formed at least 5,000 million years ago and that the age of our planet may be safely estimated at 10,000 million years.

How did life originate on this planet? That question has occupied the minds of naturalists, geologists, philosophers and other thinkers for thousands of years, without bringing them to a conclusive answer. The original records, if they ever existed, are irretrievably lost and the later records, in the form of fossil remains or casts of living organisms, while throwing some light on the gradual evolutions of types, give no clue to the origin of life itself.

Many hypotheses have been advanced in the course of time, but one by one they have fallen by the wayside, either because they lacked a logical foundation or because they conflicted with firmly established truths or unassailable theorems. One of the most attractive among the earlier hypotheses, that of the autogenetic origin of life from some hypothetical primeval protoplasm or slime, found many supporters and is still believed in by some scientists, while an overwhelming majority has abandoned it, principally because it has been found impossible to prove its correctness.

More recently, Svante A. Arrhenius, the noted Swedish chemist, has valiantly broken a lance for the pan-spermic hypothesis, which is founded upon the assumption that life did not originate on the earth, but that it reached this planet accidentally by drifting through space from some other planet. Aside from the fact that this hypothesis does not explain the origin of life, because it does not answer the question how life originated on the planet from which it drifted to the earth, the premises upon which it rests, or at least some of them, are clearly beyond the range of probability, if not of possibility.

The pan-spermic hypothesis of Arrhenius has recently been vigorously attacked by several noted scientists, who demonstrated by a careful analysis of its premises, that it is untenable. Many noted scientists in different parts of the world have recently reached the conclusion that the origin of life is a hopeless subject of investigation because we can

neither prove that life originated on earth, nor that it originated on some other planet and was carried to our planet through space.

When Hendrick A. Lorentz, the noted Dutch physicist, a few years ago advanced the hypothesis that in accordance with the theory of Relativity all molecular systems or bodies, moving with considerable speed through the resting ether, must become to some degree flattened in the direction of their motion, no definite facts were known to science to prove the correctness of that hypothesis. Prof. Dr. Courvoisier of the Babelsberg Observatory near Berlin undertook an investigation of the subject, in the hope that the result of his research would either prove or disprove the Lorentz hypothesis. As part of the research, simultaneous observations of the zenith positions of stars near the polar star were made at observatories at opposite sides of the earth, also pendulum tests, time comparisons and observations by means of the delicate gravimeter at the Babelsberg Observatory. In addition, careful comparisons were made of the star positions as recorded in the observation lists of several observatories in widely scattered localities. The data collected were analyzed and the results worked out with the greatest care by Dr. Courvoisier. The report of his investigations, recently published by him, created a sensation in astronomical circles and among physicists and other scientists in general. The results, in the opinion of Dr. Courvoisier, who had previously not been in complete accord with the theory of relativity, confirmed the correctness of the Lorentz hypothesis of a resting luminiferous ether and of an actual contraction of material bodies moving through the ether. It was found that our earth, together with our solar system, and probably the whole galaxy, interpreted as a spiral nebula, are moving through space toward the star Capella, or rather toward that part of space where we, at the present time, see that star, with a velocity of 466.7 miles a second. As a result of this rapid motion, the diameter of the earth in the direction of its motion, is shortened by 131.2 feet and as our planet revolves around its axis at a

regular rate, this means a tidal deformation of the form of the earth traveling around its circumference and completing its cycle once every twenty-four hours. Although this shortening of the diameter is comparatively small in relation to the length of the diameter, which measures in the average 7,913,325 miles, it results in a periodic displacement of the geographic location of any point on its surface and a tidelike distortion of the outer shell of the planet, which accounts for the daily deviations of the pendulum and for the slight differences in astronomical determinations of star positions and time observations made simultaneously at widely separated observatories.

The vexing problem of the sun spots has recently been brought a big step nearer to its solution by the untiring efforts of George Ellery Hale, director of the Mt. Wilson Observatory in California. A great part of the success of his investigations was made possible by the use of highly perfected instruments of observation, measurement and recording, particularly by the employment of the spectroheliograph, greatly improved by Prof. Hale. That instrument makes it possible to obtain photographs of the sun in light of a definite wavelength. The pictures thus obtained are infinitely superior to those obtained by former methods and give a remarkably clear view of the tremendous activity on the surface of the sun.

Particularly interesting are the results of the investigation by Prof. Hale into the nature and causes of sun spots. Although sun spots, first observed through a primitive telescope by Galileo Galilei in 1611, and after him, through improved instruments by many other astronomers, they remained an enigmatic phenomenon until today, although since Galilei a great many observations were made of them and careful records of their appearance, distribution and recurrence were compiled.

The periodicity of the appearance of sun spots was first recognized in 1851 by Schwabe, an apothecary in Dessau, Germany, who devoted a great deal of time to the study of the sun. By making an analysis of observation records available, he discovered that the fre-

quency of sun spots fluctuated between a minimum and a maximum within periods of approximately eleven years, but that there were occasional irregularities in these periods for which no cause could be assigned. Later observations have shown that not only the frequency but also the size of the sun spots varies greatly. Some spots observed attained gigantic proportions, one which appeared in 1858, reaching a diameter of 144,000 miles, while another, seen in February, 1892, was approximately 150,000 miles long and 75,000 miles wide. The sun spots develop principally in two belts, between 5° and 36° north and south of the sun's equator, leaving the equatorial belt practically free. These above mentioned facts, as well as the strange coincidence of sun spot maxima, with more or less vehement magnetic and electric disturbances and gorgeous displays of polar lights on our planet, were known for many years, but science was unable to offer a satisfactory explanation of the nature and cause of the phenomena observed on the sun and the earth during the prevalence of sun spots.

It was Prof. Hale's merit to ascertain new and highly important facts on sun spots, which have greatly aided science in the interpretation of the sun spot phenomena and in the understanding of their causes. In the light of his discoveries and observations, it now appears almost certain that the sun spots represent vortices of ionized gases breaking through from the interior of the sun to its surface. As these masses of gases approach the surface, the pressure which they have to overcome diminishes, causing the gases to expand. This expansion results in rapid cooling of the gases and in a diminution of their intensity of radiation. This is believed to be the cause of their appearance as dark spots on the sun's surface, in spite of the fact that careful observations have

shown that they throw out considerable light, though less than the surrounding parts of the sun's surface.

Prof. Hale realized if it were proved that his interpretations were correct, the whirling, electrically charged ions would act as solenoids and produce a magnetic field in the direction of the axis of their motion. By utilizing the principle of the "Zeeman-effect," based upon the influence of passing through a powerful magnetic field on the frequency of vibration and polarization of light rays, Prof. Hale made measurements which fully confirmed his interpretation. He found that the spots clearly have polarity and that, almost invariably the spots develop in pairs, one having the polarity N, the other that of S, at the surface end of their respective vortices.

The most important discovery in modern solar study was made by Prof. Hale, when he established the fact that during the period of a minimum of sun spots, that means, during the time when the sun's activity has reached its lowest point, the polarity of the sun spots is reversed. The following observation will illustrate the remarkable phenomenon: While during the period preceding the minimum of sun spots in 1912 the western vortices of the spot pairs on the northern hemisphere of the sun had the polarity S, the western vortices on the southern hemisphere had the polarity N, their polarities became reversed after the minimum stage was passed and the sun began to show greater activity. The reversed polarity continued until the following minimum, in 1923-1924, had passed. This seems to indicate that the complete cycle of the sun's activity comprehends not 11.2 years, but approximately 22.5 years. This discovery is interpreted as indicating that there are drifting currents of superheated matter on the sun, which change their direction and polarity periodically at regular intervals.—*E. Welleck.*

EARTH'S INTERNAL HEAT

(See also pages 100-103, Vol. II)

C. E. Van Orstrand, geophysicist, Geological Survey, discussed the possibility of utilization of the earth's internal heat as a source of power in the United States in an oral statement, made September 21, 1926.

He has for several years given special attention to the subject of instrumental study of earth temperatures and has measured, with an instrument of his own invention, the temperatures in more than 150 deep wells, nine of them more than a mile deep.

Mr. Van Orstrand's attention had been called to a recent statement of Senator Prince Ginori Conti, Italian scientist, before the International Union of Pure and Applied Chemistry, at its meeting, September 14, 1926, in Washington, in which Prince Conti described the harnessing of Italy's steam springs as a source of power for industrial uses. He expressed interest and, in a written statement, discussed the possibilities in, and the search for, subterranean heat in the United States, of which there is abundant visual evidence, especially on our western coast.

Utilization of the internal heat of the earth as a source of heat or power is dependent upon two conditions: First, a high temperature in the rocks, and, second, a large supply of flowing water. Unless both of these conditions are fulfilled at the same time, the utilization of the earth's internal heat is impossible except possibly on a very small scale.

POSSIBILITIES OF DRY WELLS

It is conceivable that a small quantity of heat could be obtained from a dry well which penetrates rocks having a high temperature. The deep well completed last year near Longmont, Colo., by A. A. Rolleston Company is interesting in this connection.

A temperature of 212 degrees, Fahrenheit, the boiling point of water at sea level, was found in this well at a depth of 6,600 feet. As the well was drilled to a total depth of 7,300 feet, water lowered to the bottom of the well would

have acquired a temperature considerably above the boiling point, possibly 230 or 240 degrees, Fahrenheit.

Had there been an arrangement of pipes such that cold water was lowered slowly into the well, and the heated water removed quickly, a small quantity of heat could have been obtained. But on account of the extremely slow transmission of heat through the rocks to the well, the development of heat in commercial quantities by this method is impracticable.

The conditions are quite different, however, when a large water bed or underground drainage area is imbedded in rocks whose temperatures are quite high; for the water in this case passes through a great volume of heated rock material and acquires a high temperature without appreciably lowering the temperature of the rocks themselves.

If, then, this underground drainage basin has access to the surface of the ground through openings that are very small in comparison with the total area drained, large quantities of heat can be brought to the surface during long intervals of time.

HOT SPRINGS AND GEYSERS

A remarkable phenomenon of this kind is to be found in the Yellowstone National Park, where the springs and geysers have brought vast quantities of heat to the surface of the earth during the past thousand years or more. A most extraordinary illustration of this kind of heat transfer is "Old Faithful" geyser, in the Park, which is known to have discharged steam and hot water at regular intervals of about one hour since its discovery in 1806 by John Colter.

In the Valley of Ten Thousand Smokes, Alaska, the temperatures of the steam escaping from fumaroles range from about 200 to 1,200 degrees, Fahrenheit. By properly confining the steam, it could doubtless be used as a source of power as was done by Prince Conti at Tuscany, Italy, when he first undertook

the utilization of the heat from Italy's hot springs.

His success in harnessing the springs led him to the second and more important stage of development, namely, the drilling of wells to tap the steam at or near its source.

STEAM AND HOT WATER WELLS

Some preliminary work in drilling for steam and hot water has been done in the United States. At Boise, Idaho, three wells were drilled to the depths respectively of 394, 404, and 455 feet. The temperature of the flowing water was 170 degrees, Fahrenheit, and was used quite extensively for heating purposes.

At Vale, Oregon, a considerable flow of water having a temperature of more than 200 degrees, Fahrenheit, is obtained from two wells each drilled to a depth of about sixty feet. The water is used in a swimming pool and a sanitarium.

Wells of this kind could possibly be used with profit to heat water approximately to the boiling point before injecting it into the boiler for conversion into steam.

At "The Geysers" about seventy-five miles north of San Francisco is a tract covering an area of about thirty-five acres overlying rocks in which the temperatures are extraordinarily high. Dr. E. T. Allen of the Geophysical Laboratory of the Carnegie Institution of Washington reports that eight wells have been drilled in this region ranging from 200 to 500 feet in depth.

The temperatures at the tops of the wells vary from about 300 to 400 degrees, Fahrenheit. A temperature of 450 degrees, Fahrenheit, the melting point of tin, was found in a closed well.

The highest pressure developed in a closed well was about 275 pounds per square inch. Four of the wells have each a capacity of about 1,000 horsepower. Steps are being taken to utilize the steam from these wells to develop power on a large scale.

DEEP EARTH TEMPERATURES

With regard to the possible extent of the development in the United States of power from natural steam, some information can be obtained from the collection of deep-earth temperature data which have been compiled by the Geological Survey. These records show almost without an exception, that the temperature of the rocks east of the Mississippi River is quite low, particularly in the Appalachian Mountains and along the Atlantic Coast.

Ordinarily it would be necessary to penetrate the crust of the earth in this part of the United States to depths of from two to four miles in order to obtain a rock temperature sufficiently high to convert water into steam. West of the Mississippi River, the temperatures rise slowly, but it is not until the Rocky Mountains are reached that anything of importance can be expected.

To what extent areas will be found in the Rockies, and in the volcanic regions of Hawaii and other island possessions, in which high temperatures are associated with underground water sufficient for commercial needs is at the moment a matter of pure speculation.

From a study of the rates at which temperatures increase with depth in the crust of the earth, it seems reasonable to believe that the Yellowstone Park waters are brought from depths between 3,400 and 8,000 feet (1.5 miles). Other evidence tends to show that the heat may be supplied in part by steam which has its source in a deep-seated, slowly cooling magma or lava bed.

These great depths suggest the possibility that deep drilling may ultimately be required to determine the extent of this new source of heat and power, and in this field of exploration it is interesting to note that the Chanslor-Canfield Midway Oil Company's deep well at Brea, near Los Angeles, Calif., has just passed the 8,000-foot level—the estimated maximum depth of the circulating waters in Yellowstone National Park.—*Courtesy of U. S. Daily.*

IDENTIFYING METALS

NON-TECHNICAL TESTS

Ability to recognize commercial metals and alloys is obviously an essential part of a welder's fund of practical information, for welding procedure varies with the different metals. Metal products in infinite variety are brought to the welding shop. Occasionally the customer may think he knows what the material is, but nearly always he does not. It is up to the welder to identify the metal in order that he may apply the proper welding methods.

Experienced welders have but little difficulty, but they do find it hard to explain just how it is done. This is quite natural, for it is based on personal reactions that can be expressed only inadequately in words. The most that can be done is to indicate in a general way the factors involved in the simple tests used in the shop. The welder can then practice these tests with known materials until the characteristic reactions of each metal become part of his general knowledge.

One useful method, that is not strictly a test, is to question the customer regarding the use of the part to be welded. To the welder with a good background of machine-shop practice, this will give much valuable information, for he will know that certain machine parts are always cast iron, others are usually steel forgings, and so on. These preliminary clues may then be substantiated by the regular tests.

These tests are as follows:

1. Appearance. This includes such general features as color and surface appearance.

2. Fracture. A fractured surface will frequently furnish all the information required.

3. Grinding wheel tests. When held against a grinding wheel, the various forms of iron and steel produce characteristic sparks.

4. Behavior under blowpipe. In the oxy-acetylene blowpipe itself, the welder has a splendid tool for identifying the various metals. Almost invariably when a dispute arises, the welder will

say, "Just let me put the blowpipe on it and I'll tell you what it is."

Since ability can be developed only through personal experience, welders desiring to train themselves along this line should apply each of the above tests to pieces of known composition, observing carefully just what takes place.

The following outline will serve as a guide, but it must be supplemented by practice in order to be of real benefit.

GRAY CAST IRON

Uses.—Gray iron is used where low cost per pound is more important than strength, where weight and stiffness are needed, and not very great strength, or where an intricate shape is desired.

Appearance.—Dull gray surface giving evidence of having been formed in sand mold (except, of course, where it has been ground or machined).

Fracture.—(Nick a corner all around with a chisel or hack saw and hit a sharp blow.) Uniform small dark gray crystals. Breaks short when fractured. A light chip with a chisel breaks off as it is made.

Grinding Wheel.—Dull red sparks that follow straight line.

Blowpipe.—Molten metal very fluid and watery. When blowpipe flame is raised, the depression in the surface of the molten puddle disappears instantly. A heavy, tough film forms on surface as it melts. Molten puddle takes time to solidify. No sparks.

MALLEABLE IRON

Uses.—Used where a material with properties intermediate between cast iron and steel will suffice; castings for railroad cars, farm implements, pipe fittings and the cheaper grades of tools.

Appearance.—Very much like cast iron but generally free from sand, and lighter in color.

Fracture.—Characteristic; central portion dark gray with a bright steel-like band at surface. The appearance at the fracture has been aptly described as a "picture frame." Much tougher than

cast iron when of good quality; does not break short when nicked.

Grinding Wheel.—Outer bright layer gives bright sparks like steel. Sparks quickly change to dull red as interior is reached. Sparks from interior section very much like those of cast iron.

Blowpipe.—Molten metal boils under blowpipe flame. After withdrawing flame, surface will be found full of blowholes. Melted part very hard and brittle with white fracture (it has been changed to white, or chilled iron by the melting). Outside sparks, center does not. Malleable iron should be bronze-welded, not welded with cast iron.

tough that it cannot be cut with a chisel, nor can it be machined.

Grinding Wheel.—Sparks are much brighter than cast iron. Manganese steel gives characteristic sparks that explode, throwing off brilliant sparklers at right angles to the original path of the spark.

Blowpipe.—Sparks when melted. Solidifies quickly.

STEEL FORGINGS

Appearance.—Smooth surface. Where surface of drop forgings has not been finished, there will be evidence of the fin resulting from the metal squeezing



CAST IRON SURFACE

CAST STEEL

Uses.—Used where high strength is desired, as in high-pressure valves and fittings. As manganese steel is nearly always used in the form of castings, it is also considered here. Its high wear-resistance is its most valuable property.

Appearance.—Surface brighter than cast or malleable iron. Sometimes with small bubble-like depressions.

Fracture.—Bright crystalline. Tough when nicked and does not break short. Tougher than malleable iron. Chips with chisel curl up more than malleable iron. Manganese steel, however, is so

out between the two forging dies. This fin is ordinarily removed by the trimming dies, but enough of the sheared surface remains for identification. All forgings are covered with reddish brown or black scale, unless they have been purposely cleaned.

Fracture.—Varies from bright crystalline to silky gray. Chips are tough, and when the specimen is nicked it is harder to break than cast steel, and has a finer grain. Forgings may be of low or high-carbon steel or of alloy steel. Tool steel is harder and more brittle than plate steel or other low carbon material.



CAST STEEL SURFACE

Fracture usually whiter and finer grained. Can be hardened by heating to good red and quenching in water. Low carbon steel, wrought iron, and steel castings cannot be usefully hardened.

Grinding Wheel.—Typical steel sparks. High carbon steel (machinery and tool steel) sparks much brighter and whiter than low carbon steel.

Blowpipe.—Sparks when melted, the

sparks increasing in number and brilliance as carbon content becomes greater.

WROUGHT IRON

Appearance.—Same as rolled low carbon steel.

Fracture.—Wrought iron has a fibrous structure due to threads of slag. As a result, it can be split in the direction that the fibers run. The metal is soft



CAST IRON FRACTURE

and easily cut with a chisel. When bent, it is quite ductile. When nicked and bent, acts like rolled steel. *Can not* be hardened by quenching from bright red heat.

Grinding Wheel.—Same as low carbon steel.

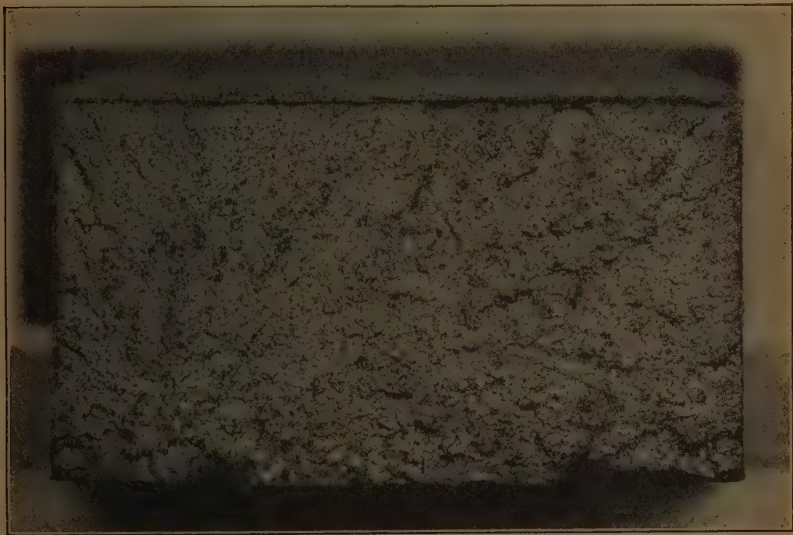
Blowpipe.—Melts quietly without sparking. Has a peculiar slag coating with white lines in it; oily or greasy in appearance.

some tendency to burst with a "sparkler" effect.

Blowpipe.—Sparks when melted. Solidifies quickly—almost instantly.

HIGH-CARBON STEEL

Appearance.—Same generally as other steels. These steels are more expensive, and work is usually done on them to give a smoother surface finish.



CAST STEEL FRACTURE

MILD OR LOW-CARBON STEEL

Appearance.—Appearance of steels depends upon method of preparation rather than composition.

Cast.—Relatively rough surface except where machined.

Rolled.—Fine surface lines running in one direction.

Forged.—Can usually be recognized on account of its shape, hammer marks, or fin.

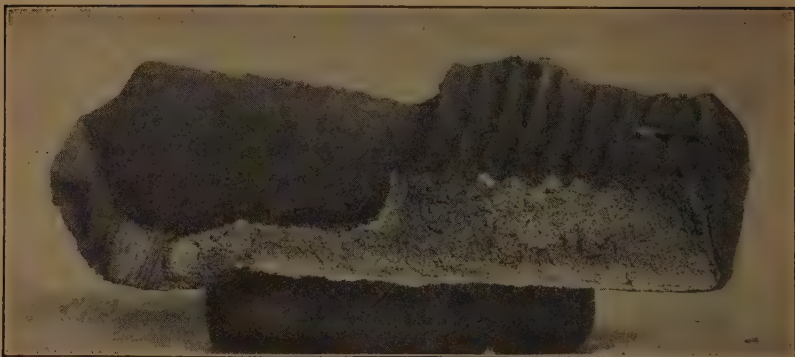
Fracture.—Bright crystalline. Tough when chipped or nicked.

Grinding Wheel.—Sparks in long streaks brighter than cast iron and show

Fracture.—Usually very fine grained fracture, whiter than low carbon. Tool steel is harder and more brittle than plate steel or other low carbon material. High carbon steel can be hardened by heating to good red and quenching in water. Low carbon steel, wrought iron, and steel castings can not be hardened.

Grinding Wheel.—Brilliant "sparklers."

Blowpipe.—Molten metal is redder than low carbon steel, and the melting surface has a cellular appearance. Sparks more freely and sparks are whiter than mild steel.



MALLEABLE IRON FRACTURE

ALLOY STEELS

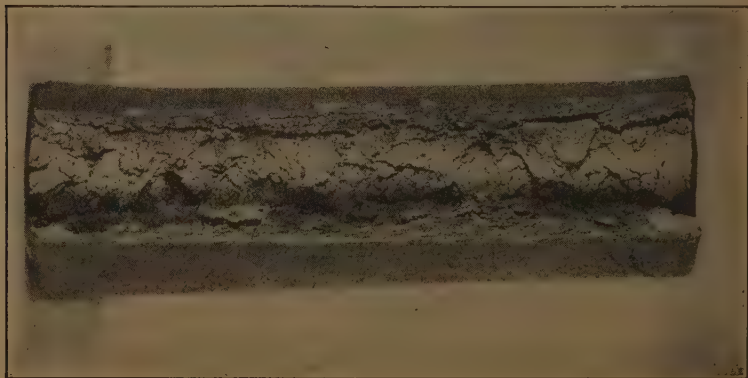
Uses.—Alloy steels are frequently recognized by the use to which they are subjected. They have greater strength and durability than other steels. A given strength in a part is secured with less weight of material than when other steels are used. Their economical use depends upon proper heat treatment which is destroyed by the welding at the region of the joint. It is well to refuse work on alloy steel automotive parts like axles and steering gears. Manganese steel is a special alloy steel

that is always used in the cast condition and is consequently considered under cast steel.

Appearance.—Same as other drop forged steels. Much alloy steel is machined all over.

Fracture.—Generally very close grained; at times the fracture might be said to have a velvety appearance.

Grinding Wheel.—The various alloy steels produce characteristic sparks, both in color and shape. With practice, many varieties of alloy steels can be recognized.



WROUGHT IRON, NICKED AND BENT, SHOWING FIBROUS STRUCTURE

Blowpipe.—Depends on the nature of the alloy. Steels containing a considerable quantity of chromium produce a greenish colored slag on the weld when cold.

ALUMINUM

Appearance.—Characteristic white color; bright when polished; dull when oxidized; light weight. Rolled and

sheet aluminum; material is pure metal. Castings are alloys of aluminum with other metals, usually zinc, copper or silicon.

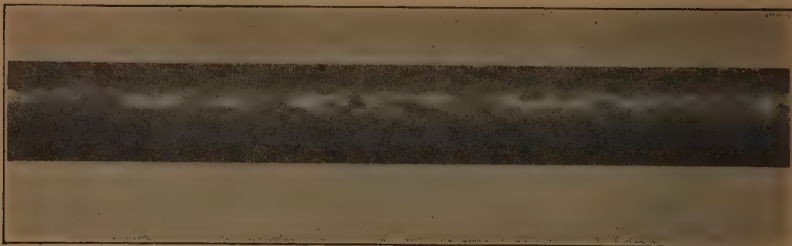
Fracture.—Castings:—bright crystalline. Rolled:—smooth and bright.

Blowpipe.—Does not show red before melting. Holds its shape until almost molten, then collapses suddenly. Heavy

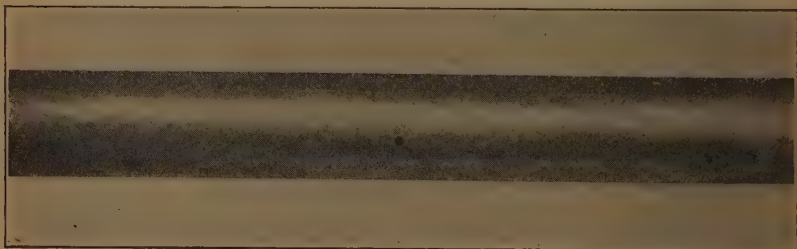


GRINDING WHEEL TEST QUICKLY DISTINGUISHES IRON AND STEEL ALLOYS

These characteristic spark diagrams are adapted from those prepared by John F. Keller, of Purdue University



SURFACE OF HOT-ROLLED STEEL BAR IS NOTICEABLY ROUGH AND SCALY



COLD-ROLLED STEEL HAS RELATIVELY SMOOTH SURFACE, FREE FROM SCALE

film of white oxide forms instantly on molten surface.

COPPER

Uses.—Used mostly in form of wire, bar, plate, and pipe.

Appearance.—Characteristic red color when polished; oxidizes to various shades of green.

Fracture.—Smooth, free from crystalline appearance.

Blowpipe.—On account of good heat-



HIGH-CARBON STEEL GIVES A VERY FINE-GRAINED, SILKY FRACTURE

conducting properties, a larger flame is required to produce fusion of copper specimen than would be needed for a steel piece of same size. Melts suddenly and solidifies instantly. Copper alloys containing small amounts of other metals melt more easily and solidify slower than pure copper.

BRASSES AND BRONZES

Uses.—Made into rolled products, like

ent, bronzes may fume slightly, but never as much as brass.

ALUMINUM BRONZES

Uses.—Used almost always as castings.

Appearance.—When polished, darker yellow than brass.

Fracture.—Smooth.

Blowpipe.—Extremely hard to weld; surface quickly covered with heavy scum



BRIGHT, CRYSTALLINE FRACTURE IS CHARACTERISTIC OF
LOW-CARBON STEEL

pipe, bars and sheet. Also castings, used rough or machined extensively.

Appearance.—Color when polished varies with composition, from red almost like copper, to yellow brass; oxidizes to various shades of green and brown.

Fracture.—Ranges from smooth to crystalline, depending on composition and method of preparation.

Blowpipe.—True brasses contain zinc, which gives off white fumes when the brass is melted. Bronzes contain tin. Even a slight amount of tin makes the alloy flow very freely—like water. Due to a small amount of zinc usually pres-

ent, bronzes may fume slightly, but is difficult to remove.

MONEL METAL

Uses.—Used either in plate, or bar form, or as castings. Its corrosion-resisting properties make it well adapted for chemical equipment, restaurant fittings, cooking utensils, turbine blades, valves and seats.

Appearance.—Color like nickel when new; dulls with age.

Fracture.—Crystalline, color like nickel.

Blowpipe.—Flows clearly without sparkling. Heavy black scale.

LEAD

Uses.—Used mostly as heavy sheet for lining purposes, or as pipe.

Appearance.—White when freshly cut; dull gray on exposure. Very heavy. Very soft. Bends easily.

Blowpipe.—Melts at very low temperature. Melted metal covered with thin dull slag coating.

DIE CASTINGS

Appearance.—Die castings are usually alloys of zinc, aluminum and tin. They are light in weight, generally white in color (like aluminum), and frequently of intricate design. Die cast surface is

very much smoother than that of a casting made in sand, almost as smooth as a machined surface. No tool marks are seen, however. Occasionally a die casting darkened by use may be confused with the malleable iron when judged simply by appearances. The die casting is, however, lighter in weight and softer than malleable iron.

Blowpipe.—Die castings can be recognized by low melting temperature. The metal boils under the oxy-acetylene flame, which is too hot for welding these alloys. With a flame of lower temperature, a die casting, after thorough cleaning, can sometimes be welded with tin as a filling metal. If necessary, the die cast part can be used as a pattern to make a new brass casting.—*Courtesy of Oxy-Acetylene Tips.*

VANADIUM

A NEW METAL PRODUCED

The commercial production of vanadium, to add to our resources was announced to the American Chemical Society by J. W. Marden and M. N. Rich, research scientists of the Westinghouse Lamp Company.

Vanadium has been known in its compounds for a long time, according to Drs. Marden and Rich, but in spite of a century of efforts on the part of chemists, no one has produced but a small quantity in its pure form. The method employed by the authors is to heat a mixture of vanadic oxide, metallic calcium, and calcium chloride in an electric furnace for an hour at a temperature of 900 degrees, Centigrade. After cooling and stirring the resulting mass in cold water, metallic vanadium is obtained in the form of beads.

"The beads of vanadium are very bright, have a steel-white color and are quite malleable, soft, and ductile," said

the authors. "They can be melted in vacuo in a high-frequency induction furnace, rolled into wire, and worked up into other shapes. As far as analysis can determine, they are 99.9 percent pure metal.

"The density of vanadium is 6, and melting point approximately 1,700 degrees, Centigrade. It is one of the least volatile of metals at its melting point. In a general way its physical properties resemble tantalum and not bismuth, as chemists have long believed.

"There is no known use for this new metal at present, but undoubtedly it will have special properties that will make it useful. Tungsten, for example, was once a useless metal, but is now of inestimable value for filaments in incandescent lamps, for high-speed tool steel alloys and many other purposes. Vanadium may, in time, prove equally serviceable."—*American Chemical Society.*

THE LIGHT METALS AND THEIR USES

The group of "light metals," which has become of enormous importance in recent years, comprises a number of metallic and semi-metallic elements, widely differing in their physical qualities, but all having in common the chemical characteristic of forming basic combinations with oxygen. Owing to their strong affinity for oxygen, none of these metals are ever found in the native state, that is, as pure metals, like platinum, gold, silver and other "heavy metals." The list of "light metals" includes the comparatively well known elements aluminum, magnesium, calcium, lithium, strontium, baryum, sodium and potassium and a number of elements like beryllium, yttrium, caesium and others which are practically unknown to the average individuals outside of the chemical profession.

Technically the most important of the "light metals" is aluminum. The history of its discovery and of its introduction to its manifold uses is highly interesting and full of the most astounding paradoxes. Although aluminum is, next to silicon (silicium), the most abundant and most widely distributed of all non-gaseous elements composing the lithosphere of the earth, it remained unknown until one hundred years ago. Its existence was suspected by several chemists near the end of the eighteenth century, but they were not successful in isolating the element.

In 1825 Hans Christian Oerstedt, a physicist and chemist at Copenhagen, Denmark, after numerous futile attempts to separate the suspected metallic radical of clay from the oxygen with which it was combined, met with partial success. He melted a mixture of the chloride of the unknown metal and an amalgam of potassium and mercury and then removed the excess of mercury by distillation. Oerstedt obtained a lump of a metallic, tin-white substance which contained potassium and mercury and, as he believed, also the suspected metallic radical. At his suggestion, Friedrich Woehler, a German chemist, continued the research and

two years later succeeded in isolating the new element by reduction of kaolin with pure potassium. He named the new metal aluminum, because it was derived from alumina, the oxide of the metal which forms the principal component of all clays.

Woehler obtained the new metal in the form of a coarse powder, which resisted all efforts to melt it and not until twenty years later did he succeed in fusing the powder into a solid lump. The first aluminum ingots, then valued at \$90 to \$100 a pound, were exhibited at the Paris Exposition in 1855 and attracted great interest, principally among scientists. At the subsequent Paris expositions in 1867 and 1878 the wonderful new metal, the cost of which had in the meantime dropped to about \$16 a pound, was represented in the form of sheets, foil, wire and finished articles.

Napoleon III., a man of high intelligence and greatly interested in literature and sciences, became intensely engrossed in the possibilities of the new element, which combined surprising lightness with considerable material strength. He conceived the idea of equipping his army with cuirasses of aluminum and conferred with French scientists in regard to the best method of carrying out his plan. He was informed that the only available aluminum ore known then, from which the metal could be extracted by the methods then developed, was cryolite, a mineral believed to exist only in a vein of some volcanic rocks near Ivigtut, West Greenland. He was also told that it would cost a great deal to mine and ship the ore and that the reduction of the ore, requiring the use of large quantities of sodium or potassium, then costing from \$40 to \$60 a pound, would make the price of the aluminum required prohibitive.

Napoleon was not discouraged by the report of his scientific advisers and sought some way of overcoming the difficulties. He sent an expedition to Greenland, to bring a shipload of cryolite to France, and offered a prize of

50,000 francs for the invention of a method of producing sodium and potassium at a more reasonable cost. The desired method of producing sodium and potassium at much lower cost was invented and soon the two alkali metals could be marketed at a fraction of their former price, but political conditions in France and the outbreak of the Franco-Prussian War prevented the Emperor from carrying out his plans.

The cheapening of the cost of sodium and potassium became of great value to various chemical industries, but it did not materially promote the use of aluminum in the arts and industries. For a number of years aluminum remained a laboratory curiosity, simply because the high cost of its production prevented its more extended use in the technical field.

The invention of an electrolytic method of extracting aluminum from its ores, by Charles Martin Hall, in 1885, gave a powerful impetus to the development of the aluminum industry in the United States. While the total production of aluminum in the United States during the first year after Hall's invention did not exceed one and one-half tons, the production increased from year to year until, in 1925, it reached 110,000 tons. In other countries also the development of the aluminum industry was aided by Hall's invention, particularly in Germany, where the Schaffhausen falls of the Rhine furnished ample water power for generating electricity cheaply and on a large scale.

Hall's invention, as important as it proved to be, was not the only cause of the enormous growth of the aluminum industry. One of the causes was the discovery of a more plentiful and cheaper ore, bauxite, which, subjected to the electrolytic process in the presence of cryolite, acting as a flux, yields aluminum of good quality. Bauxite is a rich clay first found in France and since then in many other countries. It contains iron and has the chemical composition $(Al, Fe)_2 O(OH)_4$. Cryolite, which formerly was considered the sole source of aluminum, is a sodium-aluminum fluoride of the chemical composition $Na_3 Al F_6$.

Bauxite is found in large quantities

in the United States. Deposits of this rich clay were discovered in Georgia in 1883 and those which were found in Arkansas in 1891 produce at present about 90 percent of all bauxite mined in this country. As to cryolite, of which Greenland and a few mines in the Ural Mountains still are the only known sources, the American aluminum industry is in a fair way of making itself independent of the supply of that mineral, by using in its place an artificial cryolite, synthetically produced, which is said to give excellent results.

The most powerful stimulus to the development of the aluminum industry was undoubtedly given by the World War. The isolation in which Germany found itself made it impossible to obtain certain much needed metals, like copper, tin, zinc, etc., not found in sufficient quantities in the empire. Substitutes had to be devised and the choice fell on aluminum, of which an unlimited supply was available and which could be adapted with comparatively little difficulty to fill the place of the metals no longer obtainable. Hundreds of highly trained chemists throughout the German empire joined their efforts in making a thorough research into the nature of the comparatively new metal, to ascertain how best its good qualities could be utilized and its objectionable characteristics modified or corrected. It was the stress of the most urgent necessity which initiated the new era in the history of aluminum and other light metals, the era which still continues and almost daily finds new uses for the formerly neglected metals.

The following figures, giving the approximate total production of aluminum in the world for the years mentioned, clearly show the tremendous increase in the production of that metal since the beginning of the World War:

Year	Production (Long Tons)
1885.....	13
1888.....	39
1890.....	175
1896.....	1,785
1902.....	7,800
1908.....	18,500
1913.....	65,000
1925.....	200,000

Although exact figures for the years 1926 and 1927 are not yet available, it may be stated that incomplete figures and estimates indicate a continuance of the increase in production during the past two years. As new uses for aluminum and its alloys are constantly found and, in view of the fact that the metal constitutes approximately one-twelfth part of our lithosphere, thus practically eliminating the possibility of a shortage, it may be safely said that the era of aluminum and other light metals is still in its infancy and has a great future before it.

Of all "light metals," aluminum has become the most important for structural and industrial purposes. Its name is indirectly derived from "alumen," a term which the ancient Romans applied to a group of salts with astringent taste, which included some of the salts of aluminum. This metal forms a component part of all clays and many minerals including granite, gneiss, porphyry, basalt, trachyte, feldspar, mica, turquoise, emerald, etc.

Physically and chemically, aluminum is a peculiarly interesting metal. Its atomic weight is 26.97, its specific gravity 2.70 to 2.85. Like the other elements belonging to the group of "light metals," it has a strong affinity for oxygen and could not exist for any length of time if exposed to the air, especially moist air, were it not for the fact that it becomes immediately coated with an extremely thin covering of aluminum hydroxide, which prevents further oxidation by the oxygen of the air or by that, which chemically combined with hydrogen, forms the water. Aluminum differs in that respect from sodium, potassium, calcium and other "light metals."

If the formation of the protective skin of hydroxide is prevented by amalgamating the surface of the metal with mercury, the oxidation continues until the entire mass of the metal is changed to oxide or hydroxide. The oxidation is accompanied by the development of intense heat.

The avidity of aluminum for combining with oxygen is utilized in the thermite process invented by Dr. Hans Goldschmidt of Essen, Germany, which

is used for welding or for the reduction of certain metals with high melting points. In that process finely powdered aluminum is intimately mixed with the oxide of the metal to be reduced or to be welded and placed into a funnel-shaped crucible of refractory material. On the top of the mixture in the crucible a layer of powdered magnesium metal is placed. When the magnesium is ignited, the heat produced by its combustion or oxidation acts as trigger, in bringing the aluminum powder to a state of increased energy in which it attacks the metal oxide with which it is mixed, breaks up the chemical union of the metal with oxygen and combines with the liberated oxygen to form aluminum oxide. The heat produced by this chemical reaction is so intense that the metal thus disoxidized by the reducing action of the aluminum is melted and may be used for welding or be collected in an ingot mould.

The strong desire of aluminum to combine with oxygen makes it difficult to solder the metal and impossible to deposit it by electrolysis from solutions of its salts.

At an early stage in the development of the aluminum industry it became clear that the uses of aluminum in its pure state were limited, partly because of its strong affinity for oxygen, but principally because its softness, lack of tensile strength, its comparative brittleness and other characteristics made it undesirable, if not altogether unfit, for many structural and other technical uses.

Before the World War, aluminum was scarcely more than an industrial curiosity. It was made into kitchen utensils which, when new, presented an attractive and silver-like appearance, but soon became tarnished; into sheets from which many toys and novelties were made; into foil for packing candies and other foodstuffs; into wire and various pressed or cast ornaments and into handles of surgical instruments and laboratory appliances. Because of its inherent weakness, the metal was used for structural and other technical purposes only in cases in which lightness was more essential than strength. The metal had its first important test as a

structural material in the first Zeppelin airships, built about 1890.

When the extensive use of aluminum as a substitute for other, unobtainable, metals became imperative in Germany during the World War, exhaustive scientific research was undertaken which led to highly important discoveries and laid the foundation for the tremendous development of the aluminum industry in Germany and elsewhere since the close of the war.

It was discovered that many of the undesirable qualities of the pure metal, which practically unfitted it for structural purposes, could be greatly modified and lessened or altogether eliminated by annealing or other metallurgical treatment, or by combining the aluminum mechanically or metallurgically with one or more other metals.

As the result of this research a greatly superior quality of aluminum was produced and a series of "noble" alloys of aluminum with other metals sprang into existence, among them duralumin, lautal, silumin and electron, which have already gained important positions among modern structural materials. Duralumin contains 0.5 percent magnesium, between 3.5 percent and 5.5 percent copper and from 0.5 percent to 1 percent manganese. Lautal has a similar composition. Silumin is an aluminum-silicon alloy and electron metal contains magnesium, aluminum, zinc and manganese in varying proportions. Another valuable alloy is magnalium, which consists of aluminum and magnesium and is remarkably light and weather-resisting.

Aluminum and its various alloys are now used extensively for many technical purposes. In airships and elsewhere, where lightness is essential, they are used in the form of struts, braces, lattice girders, etc. They have also found important uses in the automobile industry, for making parts of the engines and even entire car bodies of pleasure automobiles, also in the airplane industry, which employs various aluminum alloys for parts of the airplane motors, of the wings and for entire fuselages. The field of usefulness of aluminum and its alloys is rapidly expanding and with it the production and consumption of the metal.

The success of recent trials of aluminum and its alloys for the building of steam and electric railway cars, omnibuses, etc., promises a further expansion of the aluminum industry. The high cost of copper, which had heretofore been used exclusively as material of the free-air conducting cables for the transmission of high tension electric currents from electric light and power plants, has led to the substitution of aluminum cables with steel cores, which equal copper cables in conductivity and are much stronger and cheaper.

The first attempts to use aluminum plates for covering the hulls of ships were made about thirty-five years ago, but were unsuccessful, because the plates, which were made of an aluminum-copper alloy, corroded rapidly in salt water and offered only slightly more resistance to the corroding influence of fresh water. Since then, however, several aluminum alloys have been produced, which show a much greater resistance to corrosion and hold out the promise that the last word in corrosion-resisting aluminum alloys has not yet been spoken.

Reference has already been made to magnesium, which is another member of the group of "light metals." The other "light metals," calcium, barium, strontium, sodium and potassium, are principally used in the chemical industry and in metallurgy, but never for structural or other technical purposes, because in metallic form they cannot resist the corroding influences of air and moisture.

Calcium, (Ca), at. wt. 40.07, sp. gr. 1.545, is a silver-like metal of yellowish color and of high ductility. Together with barium, boron and strontium, it was discovered by Sir Humphry Davy in 1808, after he had discovered sodium and potassium in the preceding year. In contact with air or water it oxidizes rapidly under development of heat and, when brought to red heat, it burns with brilliant light, like magnesium, forming calcium oxide. Although calcium is never found in its metallic form, its compounds constitute a large percentage of our lithosphere and are widely distributed throughout the world. In the form of limestone, chalk, marble, marl and numerous other rocks and minerals,

including also enormous masses of fossil and recent shells and bones of animal origin, the compounds of calcium form whole mountain chains and vast deposits underground. Many of the calcium compounds have been known from prehistoric times and have played important roles in the cultural, economic, industrial, agricultural and scientific progress of the human race.

Barium, (Ba), at. wt. 137.37, sp. gr. 3.5 to 3.78, and strontium, (Sr), at. wt. 87.63, sp. gr. 2.5 to 2.63, in comparison with aluminum and calcium of rare occurrence in nature, are never found in the native state, but only in combination with other elements in certain minerals of limited distribution. Their uses are not as general as those of the two other light metals mentioned and are confined to a few industries, chiefly those engaged in the production of leather, fireworks, chemicals, etc. They are also used in chemical laboratory work and in metallurgical science, and more recently in metallurgy.

Magnesium, (Mg), at. wt. 24.32, sp. gr. 1.741, was discovered by Justus von Liebig and F. Bussey in 1830. It is a light, silver-white metal which is not as strongly affected by air and water as calcium, but at red heat combines eagerly with the oxygen of the air and burns to a fine, light powder, oxide of magnesium, giving at the same time a dazzling white light of great actinic power. Although it is never found in its metallic form, magnesium is one of the most widely distributed metals. It is contained, in the form of its soluble salts, in the water of the sea and in many spring waters which are used medicinally. Magnesite, a neutral carbonate of magnesium, forms extensive deposits in many parts of the globe. Combined with carbonate of calcium it is contained in dolomitic rocks which form extensive mountain chains in many parts of the world. The metal, combined with other elements, is contained in a large number of minerals and is almost invariably contained in the organisms of plants and animals. The metallic magnesium is used principally in metallurgy as a component part of many alloys, for illuminating purposes in photography and for the

making of signal lights and fireworks bodies. The oxide, carbonate and other chemical combinations of magnesium are used for medicinal and chemical purposes, the natural or manufactured silicates as lubricators, etc., in various industries and the phosphates and the potassium-magnesium sulfate as fertilizer in agriculture.

Of the other light metals only potassium and sodium are technically important. Both metals were discovered by Sir Humphry Davy in 1807 and are so similar in their physical and chemical characteristics that they may be jointly dealt with in the same paragraph.

Potassium, (K), at. wt. 39.096, sp. gr. 0.87, is a silvery white metal of the consistence of wax at room temperature and is obtained from its carbonate by reduction with carbon. Its affinity for oxygen is so great that it can be preserved in its metallic state only by covering it with petroleum. In contact with water, potassium disrupts the molecules of the water by combining with the oxygen. The reaction produces such intense heat that the liberated hydrogen is ignited and burns with a flame tinged red by the vaporized metal. The potassium oxide thus formed being easily soluble in water forms with it a hydroxide which is strongly basic.

Sodium, (Na), at. wt. 22.997, sp. gr. 0.9712, resembles potassium in appearance and in its physical and chemical characteristics very closely. It differs from the other metal only by the lesser intensity of its desire to combine with oxygen. In the case of sodium the reactions are considerably less violent than with potassium.

Both, potassium and sodium, are so universally distributed that they may be called omnipresent. They are contained in the waters of the oceans and in many springs; combined with various other elements they enter into the composition of a majority of all rocks and of many minerals and traces of them may be found in nearly all vegetable and animal matter. Both form salts with acids of every description, organic and inorganic, which are in most cases soluble in water and are chemically highly active. There is scarcely any human ac-

tivity or any organic or inorganic change in nature which does not, directly or indirectly, involve the participation of one or both these elements. It has been thus from the beginning and the discovery of the two elements in their metallic state has merely added a few new opportunities for their utilization to those that already existed.

Both metals have found an important use as reducing agents in metallurgy

and are employed extensively in the production of many of the rare metals.

The other "light metals," being comparatively rare, are more of theoretical than of practical interest, but in view of the progress of metallurgy in recent years it is by no means impossible that some of these rare metals may become of practical value in the synthesis of new alloys in the near future.—*E. Welck.*

METALS IN ANTIQUITY

CHINA

The oldest notice of the use of iron in China appears in the "Yu Kung," which may be called the geographical section of the "Book of History" and dates from 2200 B. C. Iron was then obtained in the province of Szechuen, in the region where salt and natural gas are now worked by deep borings.

The ancient records of China and Japan are also said to contain many references to the use of natural gas for lighting and heating.

INDIA

In the "Rigveda," which was written some three thousand years ago, it was stated that the god Indra used iron for his weapons and armor. Neogi advances evidence based chiefly on the "Rigveda," of the manufacture of iron in India as far back, at least, as 2000 B. C.

ASSYRIA AND BABYLON

The excavations of the French consul, De Sarzec, about 1881, in Tello, an ancient Assyrian city, and its neighborhood, carried the history of the city back to at least 4000 B. C. Copper is mentioned as being brought from the Sinaitic Peninsula in tablets during the time of Sargon, about 3800 B. C.

The wheel as a burden bearing device

and therefore metals as an accompanying necessity appeared for the first time on wheeled carts and chariots drawn by donkeys about 3000 B. C. among the Sumerians, who occupied the Plain of Shinar near the mouths of the rivers Euphrates and Tigris. This was probably earlier than in the Swiss Lake villages or on the chariot race courses of the late stone age in the West.

It is stated that no remarkable specimens of the metallurgic art of an early period have been found in the excavations about ancient Babylon, apart, perhaps, from the silver vase of Eutemena. Gold was also known, and a lead drain has been found.

One document of the time of Hammurabi, King of Babylon about 2000 B. C., mentions iron, but iron must then have been extremely rare. The oldest preserved code of ancient law is that collected and promulgated by this king, who had it engraved upon a splendid stone shaft which has survived.

Wire has been discovered dating as far back as 1700 B. C. In the British Museum there is a specimen of wire made by the Ninevites, 800 B. C.

The wire produced in the early times was flat and is not found in the round form which we now use.—*Courtesy Pure Iron Era.*

A SHORTAGE OF TIN THREATENED?

Several times during the first half of 1927 statements have been published in newspapers and magazines, that the world is threatened with a shortage of tin and that the users of tin cans are eagerly searching for satisfactory substitutes to take the place of the tin containers, in case a shortage of tin should make the price of that metal prohibitive. The whole world, especially the countries directly involved in the World War, know what a tin shortage means. Practically all countries passed through such shortage and were compelled to resort to the most desperate and by no means always satisfactory substitutions. It is quite certain, that neither the manufacturers nor the users of tin ware—and who is not a user of tin ware?—have a desire to pass through a similar crisis again.

Tin is one of the few metals known and used in pre-historic times. The so-called noble metals, gold and silver, perhaps even platinum, were undoubtedly the first metals ever used by man, for the simple reason that they were found in the native state, hence did not require any smelting or other metallurgic treatment. Copper came next in the order of discovery. All these metals were known to man as early as the neolithic, perhaps even in the paleolithic age. The bronze age, however, which followed the age of bone and stone implements, and in a comparatively short time led to the iron age, did not begin until after the discovery of tin, about two or three thousand years before Christ. That the discovery of tin must have preceded the beginning of the bronze age is obvious, as bronze is an alloy of copper and tin. Harder bronze, which, in addition to copper and tin also contained zinc, was probably the last development before iron came into use.

Where the tin industry was first developed, is not known, but it is beyond reasonable doubt that, as early as 1040 B.C., the Phoenicians and probably other Mediterranean peoples sent their frail ships through the Straits of Gib-

raltar and along the coast to Wales, to obtain tin from the mines located there. For many centuries the mines of Wales supplied the bulk of the tin used throughout Europe for bronze castings and other purposes. Comparatively small quantities were obtained from mines in Saxony and Bohemia. In China and India, the use of tin was introduced at an early period, perhaps before it was known in Europe and the supply of the metal was obtained from mines in China, Siam and India.

After the discovery and settlement of America new sources of tin were discovered, principally in Bolivia and in later years deposits of tin ore were found and developed in the Malay States, Dutch East Indies, Nigeria, Congo, South Africa and still later in Alaska.

The United States produce only small quantities of tin. So far, that metal has been found in sixteen States, but their total output in 1924 did not exceed seven tons. Alaska alone produced thirteen tons, making a total production of about twenty tons for the continental United States in that year. The output has not materially increased since then, if at all.

The mines at Land's End, in Cornwall, England, which for many centuries produced practically all the tin consumed in the industries of the world, lost their leading position about thirty-five years ago to the Federated Malay States, which now produce approximately one-third of the world's output of tin. The Malayan mines are operated by Chinese enterprise and their output may be increased in the future by the introduction of improved mining methods.

Bolivia and the Dutch East Indies each produce one-fifth of the annual output of tin, with Bolivia slightly in the lead. Nearly all the rest of the tin is produced in China, Siam, India, Nigeria, Austria, Cornwall, Congo, South Africa and Alaska. The world's total output of tin is approximately 145,000 tons a year. Of this total, the

United States alone consume more than one-half.

Of all the countries now known to contain deposits of tin ore, Bolivia seems to hold out the most promising hope of materially increasing its output of that metal. Four hundred years ago, under the cruel regime of the Spanish Conquistadores, filled with an insatiable lust for gold and silver, the mines of Potosi, Bolivia, were one of the greatest centers of production of these precious metals. Now the gold and silver mines of Bolivia are of minor importance and the Aymara Indians, who formerly worked in these mines, toil in the tin mines instead, bringing up the ore destined to enrich, not the Spanish Conquistadores, but chiefly British and American investors.

The tin deposits of Bolivia extend over a wide area in the mountains and mining experts agree that, with improved mining methods and better facilities for handling and transporting the ore, the output of the Bolivian mines could be greatly increased. Even now the mining of tin accounts for about sixty percent of the public revenue of Bolivia.

Mexico has recently been added to the list of tin-producing countries and in several parts of Africa deposits of tin ore have been discovered, the extent of which is not yet definitely known. This, together with the probability of further finds and the certainty that the productivity of the tin-mines already known may be materially enhanced in the near future by the introduction of improved methods, makes it appear that the exhaustion of the world's tin supply, or even a serious shortage, need not be feared for a long time to come, probably not for several centuries. In the meantime the chemists and metallurgists of the world will undoubtedly be able to discover one or more substitutes for tin, suitable to replace that metal in the various industries in which it is used.

Tin is a highly interesting metallic element of silver-white appearance and crystalline structure, of low tensile strength, but very malleable. Tin is its Anglo-Saxon name, while its scientific name, Stannum, is of Latin origin. The chem-

ical symbol Sn stands for Stannum, atomic number 50, atomic weight 118.7, sp. wt. 7.28, melt. pt. 231.8 degrees, C. Recent investigations have established the fact that the metal consists of a number of isotopes, varying in atomic weight between 116 and 124 and present in varying proportions.

Tin has the interesting characteristic of being dimorphic, which means that it exists in two entirely different forms of solid aggregation. One of the forms is the well known metallic form, the other that of a fine gray powder. It has been found that white, metallic tin is stable only above 18 degrees, C., while below that temperature it has a tendency to change to gray tin.

Tin is not the only element possessing this peculiar characteristic, but shares it with a few others, among them phosphorus, sulphur and selenium. This peculiarity is probably due to certain structural conditions depending upon the relative proportions of the isotopes contained in these elements.

It would be impossible, within the limits of this necessarily brief article to mention all the manifold uses in the industries, arts and sciences of this valuable metal. Reference can be made only to the most important of its technical and other uses.

The most important use of tin is in the manufacture of tin plate, out of which "tin cans" and various other articles are made. In the United States alone, four billion tons of tin plate are manufactured annually, of which a large part is consumed in making the eight billion three hundred million tin cans produced annually. Tin plate is made by dipping sheets of mild steel into molten tin, after they had been carefully cleaned.

The commonly used term "tin can" is really a misnomer, inasmuch as the tin constitutes merely one-sixtieth part of the weight of tin plate; the other 59/60 are steel.

Formerly, tin cans that had served their purpose and had been emptied, were thrown away and countless billions of them were allowed to go to waste on the rubbish heap, buried in the ground or dumped into streams, lakes or the ocean. But the shortage of tin, par-

ticularly during the World War, proved a valuable lesson and now, old tin cans and scraps of tin plate are gathered and sent to "detinning"-works, where a great deal of the tin is recovered by treating the cans and plate scraps with dry chlorine gas. The dry gas combines with the metal to form stannic chloride, which is extensively used in dye industry for making mordants, substances which cause dyes to become fixed on the fiber.

Another important use of tin is that in the manufacture of "Terne-plate," of which enormous quantities are consumed for roofing and in the automobile industry. Terne-plate is made practically in the same manner as ordinary tin-plate. The principal difference is, that they are not coated with pure tin, but with a mixture of molten tin and lead.

The comparatively low cost of tin-plate and terne-plate is possible only by reason of the inexpensiveness of the steel and because of the relatively insignificant percentage of the costlier tin which constitutes the protective coating of the steel sheets. On May 31, 1927, steel was quoted in American markets at \$33 a ton, while tin was quoted at 67 cents a pound, or \$1,340 a short ton, a price more than forty times greater than that of steel.

The first important use of tin was that for making bronze several thousand years ago. Large quantities of tin are still consumed every year in the manufacture of bronze and a large number of bronzes of varying composition has been developed in the course of time.

Bronze is usually an alloy of copper and tin, containing in addition either zinc or lead, sometimes both and, in comparatively rarer cases, other elements, like iron, antimony, phosphorus or aluminum. During the early part of the "Bronze Age" there were no specific standards for the composition of the bronze which was used for making tools, weapons, cups, containers, ornaments, etc. Soon it was discovered, however, that the physical qualities which made the alloy suitable for certain specific purposes, depended upon the metals combined to form the alloy and upon their relative proportions.

Some of the best ancient bronze contained 75 to 80 percent of copper, 3 to 8 percent of tin, 11 percent or more of zinc and some lead. Modern bronzes are, within certain limits, standardized according to the purpose for which they are intended. Cutting or hard bronze usually contains about 14 parts of tin to 100 parts of copper; mortar bronze, 93 parts copper, 2 parts of tin and 5 parts of lead; medal bronze, 89 parts of copper, 8 parts of tin and 3 parts of zinc; statuary bronze, 88 parts of copper, 9 parts of tin, 2 parts of zinc and 1 part of lead; bronze for ornaments, 82 parts of copper, 3 parts of tin, 18 parts of zinc and 2 parts of lead; gun metal contains 90 percent of copper and 10 percent of tin; bell metal, 76 to 80 percent of copper and 29 to 24 percent of tin.

Among other important alloys containing tin the following may be mentioned: soft solder, 50 percent each of lead and tin; pewter, 75 percent of tin and 25 percent of lead; Britannia metal, nearly 90 percent of tin, 10 percent of antimony and some copper; type metal, tin, lead and antimony in varying proportions.

In many of these alloys the metals of which they are composed are partly in the form of chemical combination, as for instance Cu_2Sn , and it is believed that the physical characteristics of the alloy depend in a great measure upon the extent of such chemical combination, which may be influenced in the making of the alloy by certain conditions of temperature, duration of heating, pressure and purity of the component metals. Particularly in the casting of bells, it is of the greatest importance that the metal be of the right consistency and it is a well known historical fact that the formulas for making bell metal of exceptionally fine tonal quality was transmitted from generation to generation in the families of some of the most famous bell casters.

Large quantities of tin are also used in the making of tinfoil and of the metal sheets for lining containers in which tea and other aromatic vegetable substances, certain chemicals, furs, etc., are transported on long overseas journeys. These foils and sheets are made either from pure tin or from alloys of

tin, lead and sometimes other metals in varying proportions.

Tin is also used for lining of copper vessels, pipes and chemical apparatus, in making bottle and jar caps, yellow brass for faucets and other uses, buttons and ornaments, toys and novelties. This

list does by no means exhaust the manifold uses of this valuable metal, which are constantly becoming more numerous.

It is to be hoped that the supply of tin will not be exhausted for a long time. It would be calamitous unless a cheap substitute is found.—*E. Welleck.*



A COLOR-MATCHING MACHINE MORE ACCURATE THAN THE HUMAN EYE. DEVELOPED AT BOSTON "TECH"

OUR NATURAL RESOURCES

The essentials to national prosperity are natural resources, labor and capital. The earth furnishes the raw material for industry, labor supplies the energy, and capital the economic background for complete development. America is rich in all of these. Our rapid advance as a nation, outstripping all other countries in the short period of growth from a wilderness peopled by savage tribes to what we modestly term the foremost nation in wealth and advanced civilization, has been made possible by our illimitable natural resources.

A country without abundant natural resources within its borders is like an engine without fuel. The national structure built upon foreign materials is artificial and may collapse at any time when economic or other conditions divert the supply.

The early settlers in America could not have realized that the new world offered the foundation for the greatest development of civilization in historic times. We do not ourselves know to what new uses our discovered resources may be applied, nor how those yet hidden may supply man's needs. The opening up and utilization of these treasures of the earth is after all a gradual process. Like the child's first primer, which page by page extends his intellectual horizon, the discovery and development of one resource after another discloses enlarging agricultural and industrial possibilities undreamed of a century ago.

But our natural advantages in the way of fertile valleys, minerals in the mountains, timber that had been growing when the history of the old world was young, the potential water power in the streams, and natural havens for shipping in our long coast lines would still be undiscovered wealth had not the brain of man utilized them for his benefit.

The vast treasure Nature has stored in our domain, which to us are natural resources, did not represent wealth to the aborigines in America. Wealth comes from something created for the satisfaction of man and his wants. Un-

til the resources of Nature are utilized, they are not even wealth in embryo. The primitive inhabitants of America lived in an unseen world, so far as the potential wealth of our continent was concerned. For them our natural resources did not exist, because they had no utility or trading value.

It was the dauntless white man from afar who extracted the gold from under the feet of the roving Indian; it was this same white man who stripped the forests to shelter him. He it was who detected in the courses of the Indians' canoe the mighty roar of power which was to turn motors and light great cities. He recognized the blackened crust of the earth as coal and it furnished him warmth. He scratched the rich alluvial soil, created by the erosion of the ages, and it brought him food.

The richness of the resources of Nature made man profligate, but his insatiable demands themselves furnished the motive which has uncovered other latent resources to replace those he has dissipated. The buffalo gave way to the cow as meat, fertilizer is used to restore the exhausted fertility of the soil, coal has supplanted timber as fuel, and oil is already supplementing coal and bringing its own problem of conservation or substitution.

Changing social and economic conditions bring changing demands, just as diminished raw material creates new supplies or compels man to adapt what remains of the old to better advantage. In a short three hundred years, our nation has progressed through the age of the wilderness, when aboriginal tribes survived by precarious, predatory methods; the frontier period, when the white man had not yet fashioned the tools for conquering the forces of Nature which locked up the treasure round about him; the agricultural era, when the soil furnished practically the only outlet for man's productive energy; and now we are in the midst of an industrial age, which has developed what some believe to be almost complete utilization of our natural resources.

And yet, who is competent to speak of the future in respect to the discovery and adaptability of what Nature has provided? The romance of mining has had many chapters, but the word "concluded" cannot yet be written at the bottom of the page. Whenever we fix limits, we seem to challenge Nature and new discoveries crowd the headlines.

Not many years ago a dirty, yellow mineral was discovered on the barren slopes of Western Colorado, a mineralogic curiosity to which the name of the President of France was given—carnotite. Later, this mineral, long known only in museum cabinets, became the valuable ore of radium. Infinitesimal though its content of the magic metal, the carnotite of Colorado became a blessing to suffering humanity.

In the State of Washington, a peculiar marble quarried to meet a limited demand for ornamental stone was discovered to be in fact magnesite, a valuable refractory material. These quarries, with the mines here in California, in no small measure aided the American steel industry in helping win the World War.

The most astounding instance of an unsuspected resource that is everywhere present is perhaps the finding of helium in the atmosphere. The credit of that discovery belongs to the British chemists, Rayleigh and Ramsay, but it was pioneer work seven years before in a laboratory of the Department of the Interior by the Geological Survey chemist, Dr. Hillebrand, that gave the British scientists the clue and the method that led to the discovery of this new element in the atmosphere. Later, helium, known in minute quantities in the atmosphere and a few rare minerals, was found in appreciable percentages in the natural gas from Kansas wells. Two decades later, the two technical bureaus of the Department of the Interior, under the stimulus of war demands, surveyed the helium resources and developed the process for its extraction to meet military needs.

We cannot speak of natural resources today unless we refer also to their conservation. The period of exploitation of our natural resources has passed, at least so far as the Government is concerned. The public land grabs of the

last century are a soiled page in our history, but the remaining public domain is protected for future generations. Our public coal deposits were shamelessly exploited during the last century, but since 1906 Government coal lands have been withdrawn from entry and protected by leasing. The appointment of the Federal Oil Conservation Board by President Coolidge has directed attention to the necessity of preventing a threatened exploitation of our oil deposits.

The production of petroleum from the public domain in California last year approximated six and a half million barrels, from which the Federal Government received nearly a million dollars in royalties. In California, oil, like gold, is where you find it. It is an amusing fact that several of the southern municipalities have had to decide whether an oil well within city limits is actually a bounty of Nature or a public nuisance.

Complete conservation of natural resources is not possible if the advance of civilization is to continue. There are those who believe our mineral resources to be inexhaustible, and others, like the Irish doctor who sent his bill to a lady for "curing" her husband until he died, believe in "conserving" the natural resources until we are all gone. Practical conservation is intelligent use of the endowments of Nature, and is the policy of the present administration.

The tendency of the Government at this time is toward restrictive legislation to prevent monopolies in the utilization of our natural resources. The policy of leasing mineral lands began in 1807, when Congress passed a law authorizing the leasing of lead mines on the public domain in Indiana Territory. The present general leasing law, however, more than its predecessors, not only prevents monopolistic development of our basic resources but guards against waste and is a source of considerable revenue to the Government. Under this law, enacted in 1920, the actual ownership of the mineral estate remains in the Government. Royalties, rentals, and bonuses on all mineral produced are paid the Government by operators who have secured leases. About twenty-five hundred federal permits to explore for non-

precious minerals on public lands in California have been issued, and 134 leases are now in force.

This reminds one of the complaint of President Polk in 1845 that the then existing method of leasing the public mineral lands was defective; that only about six thousand dollars had been received in four years from mineral leases on over a million acres of public land, while the expense of administration was more than four times the receipts. Compare that situation with last year's receipts of over eight million dollars under the general leasing law.

This preservation of apparently worthless minerals which may become valuable through scientific discovery becomes more important since the remaining public domain is principally valuable for its mineral content. Much of the mineral land once owned by the Government has passed into the hands of private individuals, but there still remains large deposits of valuable minerals in the public domain. Our public lands are believed to contain two hundred billion tons of coal, eight billion tons of phosphate, and oil shale from which sixty billion barrels of oil may ultimately be produced. California, of course, is still one of the large public land states. The total unreserved area amounts to over twenty-six million acres. Only two other states have greater areas of public lands.

An example of intelligent supervision of the public domain may be found in the work of the Geological Survey in classifying or appraising the lands according to their content and value. Attempts at land classification were begun a century and a quarter ago, but only within recent years has the effort been systematic and continuous. The Geological Survey undertook detailed land classification in 1906, when it discovered that valuable coal lands had been obtained under the guise of agricultural entries. Last year that bureau conducted topographical and geological surveys, water resource investigations, classified public lands and supervised mineral leasing in California at a cost of \$112,000. Fourteen topographic maps of different sections of the state were published during that period.

The potential energy in our many streams was early recognized as an asset of Nature. The abundant water power in the small streams of New England directed our forefathers toward manufacturing, but it has been only during the last decade that the advancement in electrical science has opened up the possibilities of extensive utilization of this mighty source of power. Electricity has abolished the old water-wheel and enabled us to transport the converted power for great distances, rather than confine its use to the banks of the stream. Fortunately, we have been forehanded in assuring the development of this infant industry in accordance with the public interest through control of water-power sites.

In 1920, Congress passed a Federal Water Power Act, and thereby established for the United States a policy of permanent retention in public ownership of the power sites on public lands and power privileges in navigable and international streams. It is estimated that eighty-five percent of the potential water-power resources of the United States are thus held in public ownership subject to disposition under the terms of this law. There are about six million acres reserved or classified as valuable for power purposes, and California's share is over one-sixth of this reserve.

The Colorado River is one of the great undeveloped natural resources of the United States. While its development is of particular importance to the people of California and contiguous states, the potential benefits make it a subject of national moment. It is proposed to spend two hundred million dollars of public funds in flood control, utilization of the waters for irrigation, electric energy and domestic use. The project will contribute to human welfare and create new wealth throughout the Colorado basin and tributary country.

While I am opposed to Government ownership or operation of any public utility that is within the compass of private citizens, yet for two years I have been urging upon Congress that the Federal Government without fur-

ther delay aid in the development of this mighty resource. No individual or corporation could deal with so many totally different purposes as those involved in the Colorado River project and at the same time safeguard the various interests concerned. The problem is local, interstate and international, and our people as a whole are entitled to every protection the Government can lend them in holding this mighty but limited, natural gift for their own intelligent use.

Mineral resources and water power furnish the means for industrial development, but agriculture furnishes the basis for the support of the workers. The diversity that distinguishes the development of the West is comparable only to that found in the eastern states. The West is entering upon an industrial epoch, which in time will provide markets for all the power stored in the streams and all the foodstuffs raised on the farms. It is this diversification of labor that makes a nation self-contained and insures stability. It is estimated that our population will increase to three hundred million within the next century, and a large portion of this new population will find homes in the West. In feeding this multitude the conservation and development of our agricultural lands is fundamentally important. There is only one source of water. We know how much will fall from the clouds in a series of years. We must conserve moisture by protecting our forests, restore productivity to worn-out soils by artificial means, and direct our attention to a complete utilization of new lands heretofore considered agriculturally worthless. The latter task is the duty of the Bureau of Reclamation of the Interior Department.

Agriculturally, our nation is fortunately situated. Modern civilizations have developed best in a temperate zone, such as ours, where a wide range of climatic conditions brings diversified crops. For many years the immense areas of public lands that only needed the plow to make them productive satisfied the land hunger of our growing country, but during the last fifty years there has been an increasing demand for using the lands less well adapted to farming.

Our natural agricultural lands are supplemented by vast areas of arid lands, requiring us only to utilize the rivers and storage pockets Nature has placed at strategic places for watering them, when they become even more productive than the most fertile prairie land. Other and larger areas of wet lands need only drainage to make them magically productive. We have irrigated, under public and private ditches, about twenty million acres of arid and semi-arid lands, but there remain some thirty millions more capable of irrigation. There are more than sixty million acres of swamp and overflowed lands, rich in fertility from the washings of centuries, that need only drainage to make them respond lavishly to cultivation.

Federal reclamation has existed for only about twenty-five years. Yet in that short period 1,850,000 acres have been reclaimed from the desert, and new principalities have grown up around the irrigation ditches. The gigantic conception of the Columbia basin project in the Northwest will be a development that compels our interest and challenges the imagination and in itself promises to become an empire. The crops raised on federal projects last year were valued at sixty million dollars. The contribution of reclamation to our social and economic structure cannot be estimated in dollars, and yet, considerable as it is, its chief value is its share in the conservation program necessary to protect succeeding generations. Federal reclamation has been given a new impetus by Commissioner Mead, whose ability and experience is placing our reclamation policy on a firm economic basis. He has initiated a policy for the reconstruction of the South, through reclamation of its exhausted farms, which promises more for that section of the United States than any other movement since the Civil War.

Those people are not asking the Government for appropriations of money. They are asking us to help them get back through skilled advice and direction—what they lost—the fertility of the soil.

The discovery and use of some of the treasures all about us suggest and in-

deed force the belief that the Golden Age is not behind us. It is such faith that is building up the West that will rebuild the South and East. It inspires the personnel of the Department of the Interior, striving to have their part in

every constructive move in the nation, whether the project be one of discovery and exploration, or one of development, conservation, construction or reconstruction.—*Hon. Hubert Work, Secretary of the Interior.*

POWER DEVELOPMENT

The total capacity of water wheels in water-power plants in the United States on January 1, 1927, was 11,721,000 horsepower, an increase of 544,000 horsepower for the year, according to a report issued by the Department of the Interior's Geological Survey and the Federal Power Commission.

This increase, although less than in 1923, 1924 and 1925, was greater than in any other preceding year except 1913, that being the year in which the Keokuk plant on the Mississippi River and certain other plants went into operation. The increase in capacity since January 1, 1910, is 7,800,000 horsepower, or an average of 460,000 horsepower per year.

The total capacity of prime movers—water wheels, steam engines and turbines, and internal-combustion engines in public utilities, manufactures, and mines and quarries (locomotives, motor vehicles, and water craft not included)—is estimated from data published by the Bureau of the Census for 1923 and previous years as 56,500,000 horsepower, an increase of 26,000,000 horsepower since 1910. On January 1, 1910, water wheels constituted 13.7 percent of the total capacity of prime movers, and on January 1, 1927, they constituted 20.7 percent, showing a comparatively small but nevertheless increasing proportion of water-power development.

The proportion of the developed water power requiring authorization by the Federal Government is 4,130,000 horsepower, or 34.5 percent, of which slightly more than one-third is authorized under

the Federal Water Power Act. Licenses now issued under the Federal Water Power Act provide for the development of 3,200,000 horsepower in the next ten years. In addition to these developments there will continue to be new developments and increased installations at present developments not requiring Federal authorization. Steady growth in water-power development seems assured for many years.

California, which became the leading state in developed water power during 1925, was more firmly entrenched in first place on January 1, 1927, leading New York State, her closest competitor, by about 160,000 horsepower. The State of Washington, which has held third place since 1921, was displaced by Alabama, and South Carolina displaced North Carolina in fifth place.

The report also contains diagrams showing the amount of water power developed each year from 1910 to 1926 in different sections of the United States and for the United States, also the total amount of developed water power and the total amount of primary power in the United States in electric public utilities, manufactures, and mines and quarries for each year from 1870 to 1926.

Copies of the report for January, 1927, and of those for 1925 and 1926 may be obtained from the Director of the Geological Survey. The report for 1925 contains the latest estimates of the amount of potential water power in the United States.—*U. S. Department of Interior.*

THE STRONGEST ARTESIAN WELL

One of our readers, a member of the United States Geological Survey, sends some interesting facts regarding artesian wells. Possibly some of our other readers can supplement this data with authentic details of other wells that will displace the champion put up by Mr. Meinzer.

I wish to raise the question as to what is the strongest artesian well that has ever been drilled. In other words, what and where is the well that holds the world's record in the number of gallons a minute that it discharges or has in the past discharged by artesian pressure? I have not made any thorough investigation of this subject, but in order to get something started I will give the recorded flow of a few of the strongest wells that have come to my attention. If anyone knows of a still stronger well I would be glad to hear about it so that the true world's champion may be located and duly credited. Following are the records of what appear to be some of the leading champions:

In the State of Queensland, in Australia, is the so-called Tinderry bore, which is a six-inch well drilled in 1910 to a depth of 2,500 feet. According to a report by J. B. Henderson, the State hydraulic engineer, this well when completed had an artesian pressure of 162 to 183 pounds to the square inch and flowed 2,520 gallons a minute. Thirty-eight other wells in Queensland were, in 1911, reported to have artesian flows of more than 2,500,000 gallons a day (about 1,700 gallons a minute), and one was reported with a doubtful record of 4,500,000 gallons a day (about 3,125 gallons a minute).

A number of strong flowing wells were drilled many years ago near San Bernardino, California, for the Gage Canal Company. The strongest of these, as reported by J. B. Lippincott, was a 10-inch well that was drilled to a depth of 192 feet and flowed 3,730 gallons a minute. A few other wells in the same vicinity flowed nearly as much. The

head is not definitely known but was apparently about forty pounds.

In 1896, N. H. Darton reported an eight-inch well at Chamberlain, South Dakota, which was 685 feet deep, had an artesian pressure of 110 pounds, and flowed 4,350 gallons a minute. He reported four other wells in the Dakota artesian basin that flowed three thousand gallons a minute or more.

In March, 1926, a 12½-inch well, 780 feet deep, was drilled for the Oasis Cotton Company, near Roswell, New Mexico. On April 21, 1926, A. G. Fiedler, of the United States Geological Survey, examined this well. He found that the artesian pressure was only about thirty-two pounds but that the flow, according to a careful measurement made by him, was 5,710 gallons a minute. He further estimated that when the well was completed it flowed about 5,900 gallons a minute. Thus the New Mexico well is easily the champion among these four record wells.

A flow of 5,710 gallons a minute is best appreciated by waterworks men if we say that it is equal to more than eight million gallons a day or enough to supply one hundred gallons a day to each inhabitant in a city of eighty thousand; it is best understood by irrigation engineers if we say that it is equal to nearly thirteen cubic feet a second, or more than nine thousand acre-feet a year; and it means most to oil men if we say that it is equal to nearly two hundred thousand barrels a day.

The California and New Mexico wells had some advantage over the other two in their relatively large diameters, but this advantage was much more than offset by the fact that their pressure heads were very much smaller. The Queensland and South Dakota wells end in sandstone, the California well ends in gravel, and the New Mexico well ends in creviced limestone. Apparently these gravel and limestone formations are more permeable than the two sandstone formations.—Oscar E. Meinzer, *Geologist*, U. S. Geological Survey.

ODD WEALTH STATISTICS

Uncle Sam's Domain, which includes the United States of North America, Alaska, and various trans-oceanic possessions, is reputed to be by far the wealthiest country in the world. According to the Census figures for 1922, the last available, the national wealth of the United States was estimated approximately at 321 billion dollars. The nearest approach to this figure by any other country was 130 billions, the estimated national wealth of the British Empire (in 1917), as stated by one of the Crown Ministers before Parliament. Next, in descending order, come France, with an estimated wealth of 90 billion dollars (in 1922), Germany with 40 billion dollars (in 1924), Italy with 35 billion dollars (in 1922) and Japan, with 22.5 billion dollars (in 1922).

Even before the World War, in 1912, the estimated national wealth of the United States was given as approximately 186.3 billion dollars, considerably higher than the estimate for the British Empire in 1917. During the ten years between 1912 and 1922, the national wealth of the United States increased 72.2 percent, truly a phenomenal progress in so short a time.

That this nation is enjoying at the present time a high degree of prosperity, is undoubtedly true. It is manifested in many different ways. For instance, an analysis of the effects of the revenue law of 1926 by the experts of the Treasury Department has shown, that the number of millionaires in the United States, which in 1923 was only 74 and in 1924 only 75, jumped to 207 in 1925 and there is every reason to believe that the figures for 1926, when obtainable, will show a considerable further increase.

Seven individuals occupied a class by themselves by paying taxes on incomes of more than \$5,000,000, the total tax on that group amounting to \$61,382,862. The analysis also showed that more than 95 percent of the individual income tax collections were paid by

twenty-nine hundredths of the country's population.

Under the act of 1926, which is now in effect, the number of individual returns dropped to 3,954,000, or a falling off by 3,250,000, and of those making returns a large number had no taxable incomes. In 1924, out of 7,369,788 individual returns, 4,489,698 showed taxable incomes. Under the act of 1926, the total tax collections were six percent greater and net incomes in excess of \$5,000 showed a considerable increase.

The analysis shows, that nearly one-half of the returns were filed by persons with net incomes in excess of \$95,000, and 48.5 percent of the total collections was paid by individuals with incomes above \$100,000. That means, in other words, that 10,000 persons paid about as much in taxes as more than 2,000,000 others paid in the aggregate.

Even a phenomenal increase in the number of millionaires in a country does not necessarily indicate a proportionate increase in that country's general prosperity and national wealth. The general prosperity of the people depends upon the ratio between the cost of living and the earning power and working conditions of the wageearners who constitute everywhere the overwhelming majority, the masses of the population.

A writer in the *Business Conditions Weekly* published by the Alexander Hamilton Institute, gives an analysis of the situation, in which he points out some highly interesting facts.

He states, amongst other things, that at present the cost of living is 64 percent higher than before the war, or in other words, that we now pay \$1.64 on the average for that which would have cost us only \$1.00 before the war. Wages, however, are 134 percent higher than before the war, using the index for New York State factories, so that the average wage earner now receives 2.34 times as large a weekly wage as before the war. Thus, while the wage earner spends \$1.64, he receives \$2.34. He is

able, therefore, to buy 1.43 times as much with his wage as in 1914. This represents an increase in the standard of living through the increase in "real" wages alone of 43 percent.

This improvement in conditions is mainly, though not exclusively, due to greater productivity, brought about by the use of improved methods and machinery, which enabled a man to turn out more work without increased labor. An excellent illustration is given by the following list of the percentages of increase in labor productivity since 1914 in eleven representative industries, as compiled by the United States Department of Labor:

*Increase in Productivity
Since 1914*

<i>Industries</i>	<i>Percent</i>
Iron and Steel	59
Boot and Shoe	6
Leather tanning	26
Meat packing	27
Petroleum refining	83
Paper and Pulp	34
Cement manufacturing	61
Automobiles	172
Rubber tires	211
Flour milling	40
Cane sugar refining	28

The average increase in productivity for the eleven industries included in this list is 68 percent, but in many other industries the increase was much smaller. Yet, it is believed that the average increase for all industries closely approached 43 percent, practically equaling the percentage of increase of "real" wages since 1914.

That the increase in productivity was not brought about by lengthening the working time of the wage earners is

shown by the fact that in a great number of industries the working hours have been cut down considerably during the past fifteen years. The reduction of working hours in some cases reached 35 percent. The table below quoted from the article in the *Business Conditions Weekly* shows the average percentage of decrease in the number of full-time working hours per week, and the increase in full-time earnings per week in a number of industries for which figures are available:

This remarkable improvement in the standard of living of the workers in nearly all industries was made possible principally by the use of better machinery of greater productive power. The general results of this improvement are demonstrated by data compiled by the National Industrial Conference Board. It is shown that of the total population of the United States 41.5 percent was gainfully employed in 1910, 39.4 percent in 1920 and only 37.2 percent in 1925. Hence, there has been a decrease of 4.3 percent in the percentage of the population gainfully employed. On the other hand, the figures show an almost proportionate gain in the percentage of the population enrolled in schools and colleges. This fact also materially contributes to the improvement of the wage earner's standard of living.

The striking amelioration in the living conditions of the wage earners in the United States is furthermore demonstrated by other data presented in the same publication. It is shown that the number of passenger automobiles in service in the United States in 1905 was 77,000, in 1915 2,300,000, in 1925 17,500,000 and in 1926 about 19,200,000. Assuming, that each passenger automobile is used by three persons, nearly 50 percent

<i>Industries</i>	<i>Period</i>	<i>Percentage Decrease in Hours Per Full- Time Week</i>	<i>Percentage Increase in Full-Time Earnings per Week</i>
Men's Clothing	1911-1924	18.4	181
Iron and Steel	1910-1924	18.0	117
Boots and Shoes	1910-1924	14.0	103
Woolen and Worsted	1910-1924	13.0	188
Hosiery and Underwear	1910-1924	11.8	157
Cotton Goods	1910-1924	10.0	146
Lumber Manufacturing	1910-1925	6.0	68

of the total population of the United States enjoy the use of automobiles today, compared with 7.5 percent ten years ago and less than one percent twenty years ago.

At the beginning of 1927 there were 17,600,000 telephones in use in the United States, as compared with 5,900,000 in 1910. The number of radios in use in the United States at the present time is estimated to be more than 6,500,000, while five years ago there were practically none.

Other striking evidences of the betterment of the living standards of the American wage earners may be found in the greatly improved housing conditions, better lighting, heating, ventilating, sanitation, greater comfort by the employment of electrical and other appliances for relieving the drudgery of house work, better furniture, better clothing and a large variety of amusements and diversions offered at comparatively small cost.

In an address before the Industrial Conference held at Chicago in the early part of 1927, Warner S. Hays of Philadelphia, secretary of the Clbck Manufacturers Association of America, ticked off a few interesting data illustrating the great range of earning power of workers in different trades, professions and vocations. He stated that the average income of the American working person is $1\frac{1}{2}$ cents a minute. When

all American workers waste a second, it costs \$9,980. The aggregate income of all workers in the United States is approximately \$550,000 a minute, or \$35,000,000 an hour. The range of salaries in different fields of activity show some remarkable contrasts.

President Coolidge is paid a salary of \$75,000, equivalent to an income of 50 cents a minute. From fifty to sixty cents a minute is the average pay for railroad presidents, heads of insurance companies and leading bankers. But these incomes are small compared with those of some of the movie stars. Gloria Swanson receives \$7.40 a minute for an eight-hour day, while Douglas Fairbanks and Charlie Chaplin are paid eleven cents a second, or \$6.60 a minute. Will Hays, director of the movie industry, is paid \$1.09 a minute, while former Judge Landis, now baseball commissioner, has to content himself with a compensation of 43 cents a minute.

In conclusion it may be interesting to note that the people of the United States have a great love for precious gems, particularly diamonds. More than 10,000,000 carats, with a total estimated value of \$4,000,000,000, are now owned by Americans. This makes the per capita wealth in diamonds of the United States approximately \$40, the largest in any country in the world.—*E. Welleck.*

ALMANAC

A mediaeval Latin word for a table of days and months with astronomical data, etc., and is supposed to be derived from Arabic, though no Arabic original has yet been discovered. Some early almanacs are:

Before invention of printing:
By Solomon Jarchi in and after 1150
By Peter de Dacia.....about 1300
By Walter de Elvendene..... 1327
By John Somers, Oxford..... 1380
By Nicholas de Lynna..... 1386
By Purbach 1150-1461

After invention of printing:
First printed by Gutenberg, at Mentz 1457
By Regiomontanus, at Nuremberg. 1474
By Zainer, at Ulm..... 1478
By Richard Pynson (Sheapeheard's Kalendar) 1497
By Stoffler, in Venice..... 1499
By Poor Robin's Almanack..... 1652
By Francis Moore's Almanack,
Between 1698 and 1713
Almanach de Gotha, first publ'd 1764
Whitaker's Almanack, first pub. 1868

ARC WELDED GENERATOR BASE

The success of arc-welding steel for structural work on buildings has now been applied to the construction of generators and motors.

A most impressive example, as to size, is the sixteen thousand-pound lower bearing bracket for the large Conowingo waterwheel generators. Each of these three forty thousand KVA. vertical machines is thirty-seven feet in diameter, and weighs over one million pounds. The lower bearing bracket is a ponderous cross-shaped structure 24.9 feet in diameter, with a sixty-eight-inch opening at the center for the shaft. This structure is built up of twenty-four-inch standard girders. All joints are arc-welded. The heavy cast steel brackets about the center opening are also welded on, round holes being cut in them to give greater welding periphery.

This is one of the heaviest examples of welding of this sort to date and in-

dicates the confidence the builders feel as the result of their long experience with this process.

Generators of this size are of course built at infrequent intervals, but the Westinghouse Electric and Manufacturing Company has embodied electric welding also as standard construction in an extensive line of bedplates for motor generators, ranging in size from one hundred horsepower (75 KVA.) to twenty-five thousand KVA.; a machine of the latter size now being under way. As will be seen, welding allows a very neat and strong design of bedplate, the heavy H-beams used being ideally adapted for grouting to the foundation. As in other examples of electric welded design, there is a very material saving in weight. It is believed that these bedplates represent the first completely welded work of the sort accomplished to date.



ARC WELDING PERMITS LIGHTER BASE CONSTRUCTION

NEW SOURCE OF SUGAR

Many sugars of varying degrees of sweetness are known to chemists. The one derived from beets or sugar cane is called sucrose. If its sweetening power is taken as 100, that of dextrose or corn sugar is 74.3, while that of levulose is 173.3. In appearance these three sugars are practically identical, and they have about the same food value. A few years ago the Bureau of Standards developed a method for the cheap production of crystallized dextrose from corn. The process has now been introduced in several plants, one of which is already making 350,000 pounds a day, and the demand, which comes from many large-scale industries, exceeds the supply. A market for the excess corn, which fixes the price of the entire crop, is thus rapidly developing.

Recently there has been demonstrated

by the Bureau another process of sugar making, which may prove to be of far greater agricultural and economic importance. By this process levulose, which is one and three-quarters times as sweet as cane sugar and much more soluble, is produced in crystalline form from the tubers of the Jerusalem artichoke. This is a peculiarly hardy plant, which grows well anywhere in the United States. It produces from ten to twenty tons per acre of tubers carrying from 12 to 16 percent of levulose. Plant breeders believe this percentage can be greatly increased.

The possibility of replacing ordinary sugar to any considerable extent by a superior sugar which can be grown like potatoes in New England, or generally throughout the country, is one of the utmost significance from many aspects.

FRUIT VARIETIES

How many varieties of the various hardy fruits do you know? Probably not very many in proportion to the total number of the different fruits that have been named and described at one time or another. The common commercial varieties of fruit make a comparatively short list, but when one begins running through the nursery catalogs and the horticultural magazines the great diversity of the tree and small fruits is realized.

Probably in no other publication or series of publications has so much information been accumulated about fruit varieties as in the so-called "fruit books" of the Experiment Station at Geneva. Of course, not all of these varieties are being grown at the present time, but all have been in cultivation from time to time, while new sorts are constantly coming into use.

Among the tree fruits, the pear outranks all others in the great number of varieties represented. A total of 2,929 varieties are described, of which 91 are rated as major varieties. The next in order is the plum, with approximately 1,700 varieties, followed by the peach with about 1,300 varieties, the cherry with 1,100, and the apple with 650 sorts. The grapes number about 1,500 varieties.

Each of the small fruits also shows a remarkable number of different kinds considering the fact that they have been under cultivation a much shorter time than have the tree fruits. Strawberries represent the largest group with over 1,300 varieties. Next come the raspberries with 708 kinds, followed by gooseberries with 244, blackberries with 193, currants with 183, and dewberries with 48.

A HORMONE OF THE HEART

THE SECRETION WHICH STIMULATES ITS ACTION

The study of the glands in animal organisms, particularly of the so-called *ductless glands*, is one of the most recent developments of physiology. Extensive research during the past decade into the structure, functions and secretions of the various glands has led to highly interesting and physiologically as well as therapeutically important results.

Since the beginning of this comparatively brief period of investigation new light has been thrown on the nature of these mysterious organs and on the role which they play in the economy of the animal organism. Speaking in a general way, the mission of the glands is now believed to be the maintenance of the balance within the living organism by so regulating the activities of the various organs that they work in perfect harmony.

It was learned that this object is achieved by specific secretions of the glands, which are carried by the bloodstream to the organs which, for some reason, do not function properly, causing them to return to their normal activity, and thus restoring the temporarily disturbed harmony of the organism. Not alone the structure and normal functions of the various glands were carefully studied, but also their secretions, and by numerous experiments efforts were made to ascertain the effect of these secretions on other organs. As a result of this research work the secretions of some glands, like the thyroid, the thymus, the hypophysis, the suprarenal and the pancreas, have now become an important addition to *materia medica*.

This brings us to the most recent discoveries in that field of science, that of a hormone of heart action. About three or four years ago, J. Demoor, a physiologist at Brussels, made the discovery that a watery extract from the right atrium of a dog's heart will cause pulsation in the corresponding part of a rabbit's heart, increase the frequency of the contractions and their power. Continuing his investigation, he ascer-

tained that the best results were obtained by an extract from that part of the right atrium in which the pumping action of the heart begins.

Approximately at the same time, an independent investigator, Prof. Dr. L. Haberlandt, undertook researches in a similar direction, in the course of which he obtained, by extracting the sinus venosus of the heart of a frog, a substance which he believes to be the hormone of heart action.

In his original experiment he obtained the hormone in the following manner: He cut the top part, including the sinus venosus, from the heart of a large frog, placed it in a small quantity of a physiological salt or "Ringer-solution" and allowed it to continue its pulsations in the liquid for some time. He found that the saline solution extracted during its contact with the heart fragment some substance which possessed the power not only to start heart pulsations, but also to increase their frequency and volume. The effect of the solution was found so powerful, that it caused pulsations in a frog heart which had been removed from the body of the animal two and even more than three days before, and ceased to pulsate and could not be restored to action by unenriched "Ringer-solution."

Dr. Haberlandt also obtained this hormone by extracting the ventricular base of a frog's heart with "Ringer-solution." Continuing his research, he ascertained, that the hormone is also soluble in alcohol, hence could not be of albuminous nature; that it could be dialyzed and that it is completely insoluble in ether, hence was not a lipid. He also found that it was heat-resisting and its watery extract did not lose its power by boiling. That fact strongly supports the theory that this substance belongs to the class of hormones, as it is characteristic of all known hormones to be heat-resisting. Although it was found, that the heart hormone in some respects has effects similar to those of adrenalin, it differs

from the latter by lacking the power of causing a contraction of the blood-vessels and by manifesting under certain conditions rather a tendency for dilating them.

Dr. Haberlandt is of the opinion that this hormone is secreted by the specifically differentiated muscles of the upper part of the right auricle, which may be

considered the logical seat from which automatic impulses governing the mechanism of the heart action would start. He hopes that before long this hormone will be produced in a pure state and in adequate quantities, to replace the drugs which, at the present time, are used by medical science in the treatment of weak heart action.—*E. Welleck.*

VITAMINS

HOW THEY WERE DISCOVERED

Chance helped in the discovery of vitamins, by Dr. E. V. McCollum, food scientist of Johns Hopkins University.

"I was a young fellow, just out of Yale, and was, in 1907, working at the Farm Experiment Station at Madison, Wis.," he said. "I was trying to determine relative nutrition values of the then known food elements, while mice, used in the experiments, were fed pure protein, carbohydrate, etc. But the animals did not thrive."

Dr. McCollum then placed the rodents on food element diets.

"Under this," he said, "some of the

animals flourished and some did not. It was then concluded that no animal could be healthy unless certain food were included, principally milk and the leaves of vegetables, since these foods seemed to contain most of the vital elements. An unknown food element was present, but it could not be segregated. And it has never been completely isolated. However, the experiment has demonstrated that vitamin A is present in one food, vitamin B in another and so on."—*New York Times.*

See also Vol. II, page 152.

SALT MINES

Scattered derricks giving parts of western New York the semblance of oil lands represent a much older industry than that centered in petroleum. These derricks are used for the drilling of salt.

The salt deposits in western New York underlie an area of 2,000 square miles and will last for thousands of years, it is said, though they are now yielding some 2,000,000 tons annually, almost a third of the total production in the United States. About thirty miles south of Rochester are the largest rock salt mines in the country, each of two plants having a daily capacity of 3,000 tons. If all other sources of supply in the United States should fail, these two

plants could meet the ordinary salt needs of all the people of this country and Canada.

New York also has the oldest established salt company in the United States. It has been in continuous operation since 1878. The manufacture of salt for commercial purposes began at Syracuse, then known as Salina, 130 years ago, when 700 tons were produced in one year. But ere that salt history had been made in the state. On Coney Island, as early as 1661, settlers used to fill shallow wooden vats with sea water for salt production through solar evaporation, and even before that salt springs were discovered in Onondaga County.

SEROTHERAPY

THE WARFARE AGAINST DISEASE PRODUCING GERMS

Serum-therapy, or more briefly Serotherapy, now one of the most important branches of medical science, has not yet reached the age of a century. In general terms it means the science of treating certain diseases through the agency of modified blood serum of man or other animal organisms. Although the beginnings of serotherapy in its present form as a well founded science date back scarcely more than forty years, some of the fundamental principles upon which it is based, were known, without being clearly understood, at least 2,000 years ago.

It is recorded in ancient history, that Mithridates VI., the Great, the most noted King of Pontus, in the northern part of Asia Minor, who lived from 132 to 63 B.C., knew that by taking small doses of snake poison frequently in regular intervals, he could make himself immune against larger doses which some enemy might secretly administer to him. Unknowingly, he thus foreshadowed the principle upon which Isotherapy, one of the divisions of Serotherapy, is based.

It was known for a long time, that certain infectious diseases, like measles, scarlet fever, smallpox, pneumonia, etc., rarely attack the same person a second time, but the reason for this frequently observed fact was not understood.

The pioneers in the research for the purpose of ascertaining the causes of certain widely spread infectious diseases were Robert Koch (born 1843 at Klausthal, Prussia, died 1910) and Louis Pasteur (born 1822 at Dole, France, died 1895). In the course of their investigations both discovered the presence of certain specific micro-organisms belonging to the class of fission-fungi or schizomycetes in organisms afflicted with certain infectious diseases. This class of primitive, unicellular organisms comprises the important genus of bacteria, with several divisions, among them bacilli, micrococci, spirilla, spirochaeta, etc. They generally multiply by fission, some of them, however, by spores.

Both, Koch and Pasteur, reached the conclusion that these micro-organisms were the immediate cause of the diseases in human beings and animals, which they had studied and in which they had invariably detected the presence of certain specific bacteria in abnormally large numbers. This conclusion explained in a great measure the nature of infection and encouraged the two investigators and other scientists to continue their researches on the foundation thus established.

In the early eighties of the nineteenth century, Dr. Koch discovered and isolated the bacilli of cholera and of tuberculosis, while Pasteur discovered the bacillus of anthrax. Other discoveries of disease-causing (pathogenic) micro-organisms followed in rapid succession. The research begun by this small group of scientists was taken up and extended by many others in the following years and the knowledge of pathogenic micro-organisms and of their effects upon human beings and animals, gained by the labor of these investigators, laid the foundation for that important branch of medical science known as serum-therapy. The list of early contributors to this new branch of medical science included many noted researchers, among them E. A. von Behring, Sir Ronald Ross, I. P. Pawlow, C. Golgi, P. Ehrlich, Elie Metchnikoff, Theodor Kocher, A. Kossel, C. Richet, and others.

Even in the early stages of their research, Koch, Pasteur and a few other investigators came to the conclusion that bacteria were not the only low organisms causing diseases in man or animals. They suspected that certain protozoas also were responsible for specific diseases and later investigations fully confirmed this belief. It is now known that not only bacteria, bacilli, micrococci, spirilla and other vegetable organisms belonging to the primitive class of schizomycetes may cause certain infectious diseases, but also trypanosomes and other members of the most primitive class of the animal kingdom, the

protozoa, and certain ultra-visible, filterable micro-organisms discovered by Loeffler and Frosch, two German scientists, but not yet fully identified.

Next in importance to the discovery of the pathogenic character of certain micro-organisms, came the recognition of the fact that the animal organism, after having become infected by such germs, does not passively submit to their destructive attack, but sets up a system of defenses with the unmistakable object to destroy the invaders, neutralize the poisonous substances (toxins), produced by them, repair the damage done and thus bring about the cure of the disease.

The reasons which caused infectious diseases to heal autogenously, that is, of their own accord in many individuals, leaving a state of immunity in the individual against that same disease, could not be explained at first, but became clearer through the experimental research by Koch, Pasteur, Metchnikoff and others.

It was found that, by injecting pathogenic bacteria into the human or animal organism, the specific disease for which these micro-organisms are responsible, could be produced in the inoculated individual, together with a certain amount of immunity against future attacks of the same disease. From this it was deduced, that the introduction of the disease-producing bacteria produced a reaction in the organism, causing it to liberate certain specific agents hostile to the pathogenic intruders, destroying them and counteracting the effect of the poisonous substances or toxins, which they produced.

Later it was learned that, by injecting the filtered products of the bacterial life process, the toxins, instead of the bacteria themselves, the same results could be obtained. The next discovery was that, as a result of the injection, either of the living or dead bacteria, or of their filtered toxins, certain changes were produced and new substances formed in the blood, which in some ways counteracted the effects of the injections.

The next logical step was to induce the forming of these anti-bacterial agents, or "antibodies" in the blood

serum of some animal and inject them into the organism of human beings suffering from the specific disease caused by the same micro-organism. Although this method was found to be successful in some infectious diseases, like diphtheria, its results in other diseases were not so satisfactory.

It was Metchnikoff, who by careful study with the aid of the microscope ascertained the important fact that, in case of an infection by bacteria or similar micro-organisms, the phagocytes, certain white corpuscles contained in the blood, valiantly rally to the defence of the invaded organism. They attack the bacteria, surround them with the protoplasmatic substance of their bodies and digest them, presumably by means of certain ferments, known in science as enzymes. These enzymes produce important chemical changes in the composition of the toxins of the bacteria, making them innocuous.

Later investigations led to the discovery that in some instances, following the injection of protective sera, the bodies of injected bacteria were found to be destroyed. From this the logical conclusion was drawn, that under certain conditions the blood serum could act not only as an antitoxin or antidote against bacterial poisons, but also as destroyer of the bacteria themselves, in other words as bacteriolytic agent.

Some of the investigators, who like Koch devoted themselves in a large measure to the study of that terrible scourge, tuberculosis, came to the conclusion that in the organisms of victims afflicted with tuberculosis the bacteriolytic action of the blood serum is constantly going on.

The intensive study of typhoid fever, about the same time, led to the discovery that certain blood sera have the peculiar power of agglutinating bacteria, that is, causing them to form clumps and hang together. This peculiar power was attributed to certain specific substances called agglutinins, which were present in the serum and formed one of the important defences evolved by the organism in its battle against infectious micro-organisms. This peculiar property of agglutinating bacteria has since then developed one of the most reliable

tests, the Widal Reaction, for the detection of typhoid fever.

An analysis of the development of serotherapy shows that it sprang originally from two roots. One was the discovery about 1795, by Dr. Edward Jenner, an English surgeon of Berkeley, Gloucester, that by inoculating human beings with cow-pox, they could be made immune against smallpox. The other was the observation, already referred to, that individuals who have recovered from an infectious disease often become immune against subsequent infections, and that certain individuals often enjoy an inborn, inherited immunity against certain infectious diseases. The whole structure of the now highly complex science of serotherapy sprang from and rests upon these two fundamental discoveries.

The observation of instances in which individuals naturally resisted infection by pathogenic micro-organisms, or acquired immunity against a disease by surviving a primary attack, aroused the desire of scientists, to learn the secret of the mechanism which the human organism employed in defending itself against the injurious effects of bacterial infection. The early investigations by J. Nuttall and Hans Buchner, who made a study of the anthrax bacillus in 1888 and 1889, gave interesting results which seemed to indicate that the bactericidal action of the blood serum was due to certain highly unstable substances in the serum. Later experiments by G. B. Gruber and his co-operators, who studied the nature and physiological mission of the leucocytes, or white corpuscles, and of the mysterious platelets, confirmed in a great measure the observations of Metchnikoff, who had first studied the phagocytosis, or destruction by digestion, of bacteria by certain white blood corpuscles.

To ascertain, which parts of the blood were active in the defence of the organism against invasions by pathogenic micro-organisms, experiments were made with fresh and defibrinated blood, that is, with blood from which the coagulable fibrin has been removed by beating with a glass rod or shaking with glass beads. It was found that the blood serum retained its bactericidal

power only so long as it was fresh and contained certain enzymes, highly unstable, fermentation-producing substances, for which Ehrlich coined the term "Complement". Standing for some time, or exposure to a temperature of 56 degrees C., completely destroys the bactericidal power of the serum, but it may easily be reactivated by the addition of a small quantity of fresh normal serum containing its complement.

These observations led Ehrlich to the conclusion that the protective action of the blood is due to the combined effects of two component groups of substances, the unspecific and unstable complement and the specific; stable and heat-proof substances produced by immunization, which he named "Amboceptors".

Through extensive research, R. Pfeiffer and Bessau, two German investigators, ascertained, that fresh serum, containing amboceptors and complement, had in many instances the power, not only to kill bacteria, but to counteract the toxic effect of their substance and secretions by fermentative action and, by the same means even completely to disintegrate and digest their substance.

To other investigators, Sir A. E. Wright and F. Neufeld, ascertained that certain kinds of bacteria resist the bactericidal action of the protective serum, but by contact with it are so influenced that they are easier assimilated and digested by the phagocytic white corpuscles in the blood. This peculiar action of the serum is called opsonic or bacteriotropic.

As a matter of course, the objective of the extensive research into the subject of bacterial infection was, to ascertain in the first place by what means the human or animal organism may be protected from infection by pathogenic micro-organisms and, in the second place, how an organism already infected may be cured of the disease caused by the infection. In other words, immunity, or rather immunization of the organism was the aim.

Immunity is a relative term, which refers specifically to one infectious disease only and is limited as to time and in other respects. It may be innate or acquired, either naturally, by surviving the primary attack of the disease, or

artificially, by inoculation with a specific immunizing serum. In both cases the immunity is achieved by the activity of the organism itself and for that reason it is called active immunity. In response to the natural or artificial infection, the organism develops certain specific protective substances, called antibodies, which are carried by the circulating blood to all parts of the organism where they are needed for combatting the infection. These antibodies remain in the organism after its immunization for some time, varying in duration and power in each individual case. But, no matter how small the relative number of remaining antibodies in the blood of an immunized individual may be, it may be greatly increased by again inoculating the individual with the toxic principle of the infection, against which the specific antibodies were originally formed to defend the organism.

From the blood of such immune individuals a protective serum, containing the specific antibodies, may be obtained, by the injection of which "passive" immunity against the specific disease may be transmitted to other human beings or animals. The protective effect depends upon the quantity and effectiveness of the injected serum. It becomes effective immediately after its resorption, but, as the serum was derived from blood of a foreign body, it is eliminated in a short time, together with its immunizing effect. This method is employed in the treatment of human beings and animals already infected, to aid their recovery, or to give animals immediate, though only temporary protection against infection during an epidemic.

For protective inoculations intended to develop active immunity, cultures of living or dead bacteria or extracts from them are used, which are called vaccines. By the use of these vaccines it is by no means intended to produce in the inoculated individual the disease which ordinarily follows infection by the particular pathogenic micro-organism. The object is merely to introduce a weakened, hence non-virulent, strain of the disease germs, which are intended to act as the specific antigen, that is as the substance which causes the organism to react by

the development of specific antibodies. As an additional precaution, double inoculations are sometimes employed, by first conferring upon the individual a degree of passive protection by the injection of immune serum and then follow it with an inoculation of living cultures. This method is not always safe and for that reason is almost exclusively confined to veterinary praxis.

Inoculation with killed germ cultures is not dangerous, but causes a much less intensive forming of antibodies. For that reason it is necessary in most cases to repeat the inoculation from time to time with increasing doses.

The greatest success with protective and curative inoculations has been achieved in acute infectious diseases like smallpox, tetanus, diphtheria, erysipelas, chicken-cholera, etc. Less satisfactory are the results in chronic infectious diseases, in which the progress of the disease is retarded by the pre-existing resisting power of the organism and, eventually an unstable state of balance between organism and invading germs is reached that may continue for a long time. Any method of treatment that will increase the power of the body for forming antibodies, will aid in the recovery, but the course of the disease will be long drawn out.

The oldest application of the principles of serotherapy was the vaccination against smallpox, originated by Jenner and first practiced by him in 1796. Since then many other students of serotherapy have evolved methods of combatting infectious diseases by protective inoculations. Pasteur won fame by his preventive inoculations against anthrax in sheep, which have proved highly successful and make the inoculated animals immune for one year, and by his remarkably successful inoculations against hydrophobia. Haffkine's inoculations against cholera have been successful in many cases, but their effectiveness has not yet been conclusively established. The same scientist's inoculations against the bubonic plague, however, have been eminently successful during epidemics in India and elsewhere.

Von Behring's anti-diphtheritic serum, first used in October, 1894, has proved a great boon to humanity, and Sir A. E.

Wright's anti-typhoid inoculations have been highly successful during the World War. One of the most promising recent contributions to serum-therapy is the anti-tuberculosis vaccination originated by Maragliano, an Italian scientist, in 1904. It is particularly interesting by the method employed. By the inoculation a peripheral focus of inflammation is produced in the patient, without the use of living bacilli and the organism reacts by producing active defences in the form of anti-toxins, bacteriolysins and agglutinines.

Other important serums developed in recent years are those against pyemia or blood-poisoning, tetanus, pneumonia, snake-bite, etc.

Although the progress in the science of serotherapy during the fifty years of its existence has been truly remarkable, the details of the mechanism of immunity and immunization still present many puzzling problems. But the research is indefatigably continued and new discoveries are frequently made which throw light upon some of the heretofore unexplained features of the subject.

It was known for some time, that abrin, an albuminous poison (toxalbumin) contained in the Jequirity bean, if brought in contact with the skin or the mucous membranes produced sores. But only recently it was discovered that a sore, produced by abrin on the conjunctiva of a rabbit's eye, and allowed to heal of its own accord, left the same conjunctiva immune against abrin, while the skin of the rabbit, its mucous membranes and even the conjunctiva of the other eye remained as sensitive against the poison as before.

Cattle, horses, sheep and other domestic animals are effectively protected against anthrax by inoculation with weakened strains of anthrax bacilli. But all attempts, to immunize guinea pigs by inoculation with anthrax bacilli, failed although it was shown that the same animals could be fed large quantities of live anthrax bacilli without injury.

Instances like the two mentioned above, induced A. Besredka, a noted physiologist in Paris, to investigate these phenomena and ascertain their causes. He reached the conclusion that certain

specific relations exist between certain pathogenic micro-organisms and certain cells or tissues of the living organism, which cause these cells or tissues to be highly sensitive to attacks by these germs and to develop local immunity against them under favorable conditions.

By numerous tests, Besredka ascertained that the skin of the guinea pig is the only part of its body that is susceptible to infection by the anthrax bacillus and that it may be locally immunized by appropriate treatment. He also established the peculiar fact that the blood of the immune guinea pig does not contain any antibodies.

In the case of bacterial dysentery and typhus, Besredka found that the specific bacilli of these diseases had an exclusive preference for the mucous membranes of the intestines and the gall bladder and recently he succeeded in developing a method of producing local immunity by introducing dead bacilli of the disease directly into the intestinal tract.

Particularly interesting were the results of Besredka's investigations relating to the pyogenic germs (streptococci and staphylococci) which cause furunculosis, carbuncles, abscesses, puerperal fever, sepsis, etc. He found that these germs have specific relations to the skin and that the infectious diseases caused by them could be successfully cured by the use of bandages soaked in bouillon cultures of the corresponding pyogenic germs, killed before being applied.

In the course of the experimental research from which the science of serotherapy was evolved, a series of peculiar phenomena came to the notice of the investigators, which seemed to conflict with the accepted principles of the science and could not be explained at first. Recently, however, the careful study of such cases, by Storm van Leeuwen, Staehlin, E. Neufeld, Doerr and others led to a better understanding of their true character, although even now many of their peculiar features cannot be fully explained. The phenomena referred to include the so-called allergic diseases, resulting, as it is now believed from idiosyncratic hypersensibility.

The study of hypersensibility or idiosyncrasy was taken up by E. A. von

Behring in 1900. It was known for many centuries, that the ingestion of certain foods, among them eggs, fish, meat, butter, milk, crabs, lobsters, oysters, strawberries, etc., produced in certain individuals more or less serious symptoms, principally redness of the skin, itching eruption often accompanied by fever and swelling of the joints, nausea, vomiting, diarrhoea and in some cases difficulty of breathing, palpitations of the heart and unconsciousness sometimes lasting five or six hours.

Similar symptoms are produced in certain predisposed individuals if microscopic particles of certain substances, like flour dust, pollen of certain grasses and other plants, fine particles of the skin or hair of certain animals, etc., come in contact with the mucous membranes of their eyes, nose, or enter the bronchiae and lungs in breathing. Probably the best known and most widely spread of these idiosyncrasies is the allergic disease known as hay-fever. It is now generally believed, that asthma also belongs to that group of allergic diseases and is in most, perhaps in all cases caused by the hypersensibility of the organism against certain finely distributed substances carried by the air.

Several interesting observations in the field of serotherapy, together with other observations in the study of allergic diseases, seemed to point to a similarity of the laws governing the mechanisms of immunity and hypersensibility and led to the recognition of the apparent fact that both presuppose the existence of specific antibodies.

It was found, that hypersensitiveness against any specific substance could be transferred from one individual, human or animal, to another by inoculation with serum from the blood of the hypersensitive organism. The parallelism with the action of immune serum containing the antigen against a specific infection, seemed obvious. The fact that in recent investigations specific antibodies were proved to be present in the serum of persons with an idiosyncrasy against certain foodstuffs and other substances, including certain comparatively simple anorganic chemicals, confirmed this parallelism. The tuberculin test for

tuberculosis, originated by Dr. Robert Koch in the eighties of the past century, also supplied a confirmation. Tuberculin is an extract of tuberculosis bacilli. Even one-one hundred thousandth of a milligram of that extract, injected under the skin of a person suffering from tuberculosis, produces a characteristic inflammation, while a healthy individual shows no reaction although one whole gram of tuberculin were injected. In other words, every tuberculous individual is hypersensitive against tuberculin.

As it was generally accepted by scientists, that only albumens and other proteins of similar structure could be carriers of antigens, it could not be explained at first, that simple chemical substances, like iodine, arsen, quinine, aspirin, morphine, etc., could act as antigens producing violet reactions in individuals hypersensitive against these particular chemicals. An explanation was found in the recent discovery, that even chemical substances of simple structure, provided they are in a certain manner combined with albumens or proteins of similar structure, can aid in causing the formation of antibodies and react with them specifically.

This new interpretation of hypersensibility and the recognition of its direct connection with the principles forming the basis of serotherapy is one of the latest achievements of this branch of medical science and has already led to marked progress in the successful treatment of allergic diseases.

Serum-sickness, which manifests itself in some cases five to seven days after injection by skin eruptions, swelling of the joints, difficulty in breathing, rapid pulse and fever, is now recognized as one of the reactions of the organism against the injected serum. The symptoms strikingly coincide with the typical symptoms by which the organism reacts against any other substance to which it is hypersensitive. What distinguishes these reactions from those of the normal organism is their suddenness and the almost explosive energy with which the antibodies present in the body act on the ingested or injected antigen.—*E. Welleck.*

MATCH MANUFACTURE

John Walker's rebellion against flint and tinder gave the world its first friction match and established 1927 as the centennial year of this important contribution to the convenience of civilization.

Walker was an English druggist, with a prosperous store at Stockton-on-Tees. His rebellion was stirred up by the bother of striking fire with spark and tinder every time he wanted to light his pipe. Under this stimulus he invented a match that would ignite through brisk rubbing. His ingenuity made him the pioneer in his field.

This British druggist took his idea from the war rocket invented by Sir William Congreve, used with marked success by the armed forces of Great Britain during the early part of the nineteenth century. In 1827 Walker figured that the blaze of the rocket could be duplicated at the end of a small stick to provide a simple bit of first aid to the smoker.

The idea was good, even though its first application was crude and clumsy. The first match was a wooden splint coated with sulphur and tipped with a

mixture of gum, chlorate of potash and sulphide of antimony. A boxful retailed for an English shilling, or 25 cents in American money. A slip of glass paper went with each box. To strike one of the matches the user drew the stick swiftly between the pressed folds of the glass paper and the tip burst into flame. The match was primitive but useful.

Walker's matches came into the British market as "Congreves," in recognition of the source of the druggist's inspiration. The word "match" was applied later, because of the long established use of this word for designating a candle-wick or any other object that carried fire.

When Congreves came into the market the world was using an improved tinder box in connection with splints of wood tipped with sulphur. Sparks emitted by the striking of flint and steel were made to fall into charred fragments of cotton and linen, causing this tinder to glow with enough heat to ignite the sulphur tips and set fire to the splints themselves.

Walker's invention was the first step



All photos courtesy Diamond Match Co.

AVERAGE TRAIN LOAD OF 3,200 BOARD FEET



FEEDING BLOCKS

in a cycle of match-making. In 1830 a match called the "promethean" was devised by Samuel Jones, of London. Jones followed the lead of a French chemist, Chancel, who had employed sulphuric acid as an agent of ignition. The Chancel method was complicated, and savored of the laboratory. Its application called for a bottle, in which there was a bit of asbestos saturated with strong sulphuric acid. Into this receptacle the chemist dipped the end of a splint coated with sulphur, sugar and chlorate of potash. Contact with the acid caused the tip to burst into flame, creating fire through chemical action.

Samuel Jones fashioned a match which carried its own sulphuric acid in a small glass globule enclosed in the end of a short roll of paper tipped with sugar and potassium chlorate. The user of this device was saved the trouble of carrying a bottle. His sole responsibility was to pinch the end of the paper roll, break the glass and permit the acid to come in contact with the tip.

About this time there came an epidemic of inventions dealing with phosphorus as a base for friction matches. The innovation gained widespread vogue, but the popularity of the new product brought stark tragedy for workmen employed in the match factories. The phosphorus was deadly poison to the men, women and children who per-

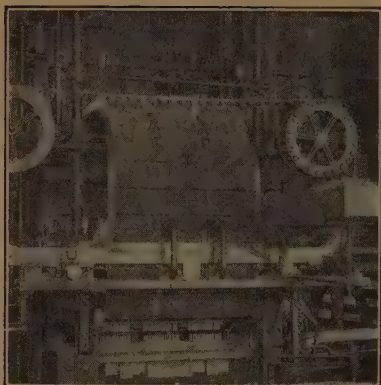
formed the labor in these plants. Exposure to the vapors produced a disease no less horrible than leprosy itself—the "phossy jaw" of the nineteenth century. The ailment was so repulsive that experienced physicians turned sick while examining its victims. Attacking an imperfect tooth, the poison caused swift decay of the entire jawbone, sometimes resulting in death after years of lingering torment.

For three-quarters of a century the match manufacturers struggled to reduce or eliminate the menace to their working forces. One step was achieved by the use of red phosphorus, a substance lacking the poisonous effects of the white phosphorus originally employed. Another advance came with the invention of safety matches, striking nowhere but on the surface of a prepared box. These inventions reduced the hazard to workers but the world still demanded matches that would "strike anywhere" and the deadly white phosphorus continued in use until governments resorted to legislation prohibiting its utilization.

In the United States the ravages of the phosphorus disease stirred Congress, state legislatures and insurance companies. The need for stringent action had achieved widespread recognition, and in 1911 the situation developed a congressional bill taxing white phosphorus matches out of existence.



SAWING AND SORTING BLOCKS



CUTTING AND SETTING IN PLATES

The proposal created a dramatic tangle. There was but one company in the United States that could survive such legislation. This concern held patents covering the use of a non-poisonous substitute for white phosphorus. Under the proposed law the holder of the patents would have been in position to dominate the match industry by charging heavy royalties for the use of its process by other manufacturers. Congress hesitated to create a monopoly of this type, and the movement for protecting the lives of workers came to an abrupt and stubborn halt.

The solution of the tangle was as dramatic as the condition itself. Securely entrenched behind its undisputed patents, the dominant corporation made voluntary surrender of its rights and dedicated its patents to the people of the United States. The surrender enabled every match manufacturer in the country to operate without endangering the lives of his employees, and permitted him to avoid marketing matches known to be poisonous and dangerous. A law against the use of white phosphorus came as an immediate sequel.

Human welfare was not alone in its subjection to the menace of the matches of a few generations ago. Until 1860 the railways of the United States refused to handle matches designed to strike anywhere. The product of that

period was so imperfectly made that its transportation by rail was a source of grave peril resulting from fire and explosions. The natural outcome of this situation was that match manufacture was a local industry, with the output sold from house to house in the immediate neighborhood of each plant.

Another serious objection to white phosphorus was its danger to human life in the household, as shown by the deaths of many children from eating or sucking the heads of matches. The domestic fire menace was similarly grave, because of the ease with which the heads ignited when gnawed by rats or mice. The match of today lacks these dangers. The absence of white phosphorus eliminates the threat of poison, while the present type of match is immune to the ravages of rodents. Actual tests have shown that starving rats or mice will eat one another before nibbling the match of up-to-date manufacture.

A century of match production has brought amazing changes in the detail of manufacture. Until the days of the Civil War the wooden splints were sawed by hand, gathered in bundles and dipped into the chemical compositions employed for creating ignition. The match-making machinery of today was unknown.

In the up-to-date match factory the output is the work of mechanism which performs miracles of production. Not



PUTTING THE TIP ON THE MATCH

least among the improvements is the air-conditioning of factory workrooms, guaranteeing uniform atmospheric conditions at all seasons of the year and in all states of weather. Until well into the twentieth century match factories could not operate in summertime nor in periods of low humidity, while the product was small and erratic when the humidity was relatively high. Mechanical and chemical changes of the present generation eliminated these difficulties and gave the match industry a basis of continuous operation.

The modern machine produces matches at a rate of 12,000 to the minute or close to six million for an eight-hour

are made at a rate of 250 to the minute.

Securely held in the links of the traveling belt the sticks move forward to receive a bath in a chemical solution at high temperature, to fortify them against the after-glow which constituted one of the fire hazards of the matches of a previous day. The next step takes them through a drying chamber, from which they enter the paraffin bath which heightens combustibility.

Then comes the process of providing the heads which change the strips of wood into the matches of commerce. The usual method calls for double dipping—first with potassium chlorate composition and then with the phosphorus which forms the tip. Separate baths are required, with sufficient intervening distance to permit the initial composition to dry before the application of the second.

The dipping is followed by a series of maneuvers in which the machinery acts with human touch. As the belt passes over a series of reels, the matches are tilted into various positions at many angles, causing the pasty tip to solidify into perfectly round heads under the drying action of an airblast.

By the time the drying process has been completed the matches are back at the starting point, where they are expelled from the plates in which they have traveled, and where they pass through automatic packing machinery. The packing involves filling the boxes to the utmost limit, to exclude air in the interest of fire prevention. The close packing is accomplished by the matches within the box in half-and-half fashion, some of them with heads pointing one way and the remainder with heads pointed in the opposite direction.

The exclusion of air is carried through the entire packing process by gluing the ends of the cartons carrying the filled boxes, and by gluing the joints of the cases in which the cartons themselves are packed. The result of this care and precision is found in the slight headway made by an internal blaze that may be caused by sharp concussion against a case of matches in transit. Tests have shown that a case may be dropped fifteen feet to a hard pavement without causing the ignition of more than half the matches in one individual



PREPARING COMPOSITION FOR THE HEADS

day. This enormous output is delivered in the form of boxed merchandise, ready for shipment.

One end of the machine receives wooden blocks, match-length in thickness. The initial operation subjects each block to the action of a hollow die, containing forty-eight little circular knives, descending from the upper part of the machine and stamping, or "gouging" out forty-eight match sticks with each downward stroke. On the upward journey the die carries a splint in each mouth, and forces the upper ends of the sticks into perforations in a steel plate traveling as one link in an endless belt five hundred feet in length. The strokes

box. The flames from these exhaust the supply of oxygen and the fire dies out without damage.

This freedom from fire menace has led to interesting experiments by the largest match company. To demonstrate the non-combustible character of the packages the corporation's testers have placed cases of matches in an actual fire for periods of five minutes without ignition of the contents.

Match manufacture begins in the

care and to leave the less perfect pieces for the other users.

After the logs pass through the sawmill, the planks are piled together for two years of seasoning, with periodical re-piling and inspection. When the acceptable boards reach the match factory they are sawed into the two inch blocks designed for the match machine, and the blocks are placed within storage bins for further seasoning and curing. No blocks reach the machine unless rigid



A TYPICAL POND AND SAWMILL; 5,000,000 FEET OF LOGS ARE IN THIS POND

forest. There is general belief that matches are a by-product of planing mills and other wood-working factories, but the actual practice demands that this idea be reversed and that sashes, doors and blinds shall be regarded as by-products of the sawmills which produce match material.

This curious reversal is due to the circumstances that the match industry insists upon using lumber of the highest grade. Matches that crumble and break in the hands of the user are not popular. The result of this condition causes the match factory to choose its timber with

examination shows them to be perfect for their purpose.

A single corporation manufactures more than half of the matches produced in the United States. To assure its permanent flow of timber this concern owns its sources of supply in the form of vast tracts of forest.

A century of growth finds the United States consuming matches at a rate of seven a day for each man, woman and child—or a total annual consumption of more than two hundred and fifty billion matches in this country alone.
—N. C. McLoud.

WOOD PRESERVING

WHICH HELPS FOREST CONSERVATION

We have for our best example in the preservation of wood the results accomplished by the railroads, for, under 400,000 miles of track in the United States, there are approximately 1,100,000,000 wooden cross-ties (the equivalent of 40,000,000,000 bd. ft. of lumber) and of these approximately 730,000,000, or 66 percent, are treated cross-ties. It is stated that the average life of an untreated tie throughout the country is seven years. Hence, if nothing but untreated ties were being used, the railroad requirements each year would be approximately 157,000,000 ties; but they have made such progress and have secured such splendid results from treatment during the last twenty years that the total requirements for both untreated and treated ties have been cut to around 100,000,000 ties annually, or a saving of 57,000,000 ties annually, representing, at today's cost, approximately 60,000,000 for the ties (wood only).

In twenty years the gain in the use of treated ties has been at the average rate of 2 percent annually. The railroads in this country are now inserting on tracks nearly 65,000,000 treated ties per year, and, if they continue at this rate, they will provide all tracks with treated ties in another ten years. When all tracks have been fully provided with treated ties, the total tie requirements hereafter will be at the rate of about 100,000,000 treated ties per year for a like amount of track. This demonstrates a saving of approximately 100,000,000 ties per year.

In discussing this subject the other day with a very prominent railroad engineer, whose road has been using all treated ties for sixteen years, he mentioned that when they first started to creosote their ties they anticipated getting a sixteen-year life from the ties. The sixteen years have passed and not one tie has decayed. Now they anticipate twenty-four years' service in the track, with the thought that should it be necessary to take the ties out of the main-line track in twenty-four years,

due to mechanical wear, they will turn the ties over, put them into second-class track or sidings, and get further life.

In view of the extended life which some of the European ties have given of over forty years in the track, it is possible that some of the creosoted ties will give the same life in this country.

The progress in the treatment of ties has all been in favor of creosote, yet splendid results have been secured from ties treated with zinc. The problem of what preservatives and processes should be used depends on the species of wood, the climate, the nature of the roadbed, and the money available for investment in treated ties; therefore, each railroad has its own problem.

Since 1909 we have treated over 3,000,000,000 bd. ft. of construction timbers and miscellaneous material in this country and we are now using 400,000,000 bd. ft. of this treated material annually, which is more than 6½ times the amount of material treated for the same purposes in 1909—an average gain of 38 percent per annum—yet the quantity now being treated is only 1 percent of the total lumber cut. Even this small quantity, at 5,000 bd. ft. per acre, represents a saving in the cut of 54,000 acres of virgin timber land annually; hence the use of treated material for these purposes has only started and there are tremendous possibilities for the use of treated material for all construction.

There is being used each year for the construction of marine docks, trestles, and bridges approximately 16,000,000 lin. ft. of creosoted piling, which is about 2½ times the amount treated in 1909, and, during the period from 1909 to date, there has been treated about 200,000,000 lin. ft.

With few exceptions the first cost of creosoted wood piling is less as compared to concrete and steel and it is the most economical and flexible for construction. Untreated piling in some marine structures has been destroyed in 2½ months, whereas thoroughly creosoted piling has been in marine service

for more than thirty years and in fresh-water service for more than forty-eight years. For fresh-water and land service, creosoted piling is considered permanent construction. This field alone shows better than thirty to one in favor of creosoted piling for permanent marine structure and over twelve to one for land service. Untreated piling should never be considered, especially when it takes more than one hundred years to grow a pile.

Our telephone, telegraph, railroad, and power companies have made great progress in the treatment of poles, for they are now treating 2,500,000 poles annually, which is $6\frac{1}{2}$ times the number treated in 1909. About 3,250,000 poles are used annually. Good creosoted pine poles in the South will give a life of thirty years and in the North of fifty years.

Since 1909 we have creosoted approximately 13,000,000 pieces of cross-arms—an average of 770,000 pieces per year—and are now treating over 1,000,000 crossarms annually, which is fifteen times the number treated in 1909. It is estimated that about 10,000,000 cross-arms are used annually, of which only 10 percent are now treated.

Many of the railroads have been using fence posts treated with creosote or zinc chloride during the last ten years, for such treated posts become nearly permanent and reduce the loss by fire. Some fence lumber has been treated to preserve it against decay and weathering.

The less durable local woods can be used for fence posts and fence lumber and, when thoroughly treated, last many times as long as the untreated. Creosoted sap pine posts have been found in good condition after thirty to forty years in the ground, whereas, if untreated, they would give only two to five years' service.

It is estimated that 900,000,000 posts alone are used each year and, if they were all treated, it is perfectly safe to assume that the life would be tripled, thus reducing post requirements annually to around 300,000,000, representing a saving in the cut on 25,000,000 acres of wood lots or second-growth timber land. This acreage, when carefully con-

trolled by the increased growth, would provide about 9 percent of the railroad cross-tie requirements in another ten years.

Untreated lumber in cars gives an average life of six years, whereas, if thoroughly treated, it is possible to get twenty years' life or more. Thus treating car material would more than triple the life, and on this basis it would save two-thirds of the present lumber used in the construction of cars, which represents the cut on more than 225,000 acres of virgin timber land annually.

It costs less to construct composite wood cars as compared to all-steel cars, and the corrosion of the all-steel cars is a serious problem, especially in coal cars. Some of the large railroads are now treating with creosote, zinc chloride, and other salts the lumber entering into the construction of stock cars, refrigerating cars, box cars, coal cars, ballast cars, flat cars, housing cars, and cabooses, and it is quite evident that during the next few years the increase in the treatment of material for cars will develop rapidly. It was thought that the treatment of lumber with creosote, zinc chloride, and other salts would be objectionable in the construction of refrigerating cars and box cars, but all these objections have been overcome and it now becomes a problem of first cost and the convenience for securing the necessary treated material promptly and as needed for car construction and maintenance.

The Census Bureau Reports for 1923 mention that the timber consumption for all mines is equivalent to 2,600,000,000 bd. ft. annually, of which about 25 percent is sawed lumber and the balance round. If this were all cut from virgin timber, at 2,500 bd. ft. per acre, it would require more than 1,000,000 acres of land annually.

A few of the coal mines have been treating their wood for permanent construction for several years, and it has been demonstrated that in many mines the less durable woods will decay to such an extent that in a year their strength is gone and therefore they are dangerous and of no use, whereas, when treated, they will give more than nine years' life.

There are approximately 900,000,000 cu. ft. of timber in all the mines in this country, which require approximately 100,000,000 cu. ft. of untreated timber each year, and there are possibilities for treating and extending the life of 165,000,000 cu. ft. each year, thus showing a tremendous saving in the cost of mining, and conserving for other purposes more than 500,000 acres of virgin timber land.

Lumber houses are most sanitary and comfortable; furthermore, their design can be easily adapted to suit the individual. Lumber dwellings, when properly constructed, are flexible, strong, and have great resistance to destruction by hurricanes and earthquakes.

The white pine, chestnut, cedar, and longleaf yellow pine, which were formerly used exclusively in the East and South, are now very difficult to secure for all purposes, which has resulted in the less durable woods being used, although little thought has been given to their protection against decay, the ravages of insects, and fire hazard.

There is a great field for conserving all this lumber, and when properly treated it will become permanent construction. In fact, in certain parts of the country where lumber is destroyed by termites it is going to be absolutely necessary to treat the lumber.

CONCLUSIONS

The preservative treatment of wood to prevent decay has increased 334 percent in twenty years, or at the average rate of 16½ percent annually. The total material treated in 1926 will run about 1,600,000,000 bd. ft., thus reducing by treatment the cut on 700,000 acres of timber land annually. There are possibilities for increasing this treatment by 28,500,000,000 bd. ft., or to a total of 32,000,000,000 bd. ft. annually.

To produce 32,000,000,000 bd. ft. annually now requires the cut from 10,-

000,000 acres of virgin timber land. Should all this be systematically treated, the requirements could be produced on 3,500,000 acres of virgin timber land, thereby saving and prolonging the life of 6,500,000 acres annually.

In addition to this 32,000,000,000 bd. ft. of treated material there is required annually for all other uses 22,000,000,000 bd. ft. of wood, making the total consumption 54,000,000,000 bd. ft. annually and making the total requirements 7,500,000 acres of virgin timber annually over and above the necessary timber land required to provide the treated cross-ties, mine timber, posts, poles, and piling.

It is stated that there now remain in our forests 138,000,000 acres of virgin timber and 250,000,000 acres of second-growth timber; therefore, with the system of conservation mentioned herein we still have in the forests a possible cut of fifty-two years, assuming that the annual growth will take care of any increased demand. But should we neglect to treat all timber and conserve our forests, in another thirty years nearly all our best timber will be of the past.

The present preservative treatment of wood is now showing a saving of \$175,000,000 annually, of which the railroads' proportion is about \$150,000,000. This represents \$375 per mile of track, or the cut on 1¾ acres annually.

When all tracks are filled with treated ties—say in ten years—and if the total of 32,000,000,000 bd. ft. is treated annually, the saving will be approximately \$1,000,000,000 annually, of which the railroads' proportion will be around \$400,000,000, representing 1.8 percent of the present outstanding railroad securities. The total saving per capita in this country will be about \$9 and 175 bd. ft. annually, thus reducing our total per capita lumber requirements to around 125 bd. ft. annually.—*Grant B. Shipley in Wood Preserving News.*

WOOD FLOUR

MANUFACTURE AND USES

Approximately twelve million pounds of wood flour is imported annually from Europe into the United States.

This is made from nothing more than sawdust, shavings and other mill waste which in this country is generally regarded as a liability and a fire hazard. While American operators are spending money to dispose of this class of material, European lumber manufacturers are converting it into wood flour, exporting it to this country, paying duty and evidently selling it at a profit.

European wood flour is claimed to have certain advantages over the domestic product, but the validity of the claim is questionable, and increased experience and care in the selection of raw material on the part of American manufacturers should result in a product in every way equal to that produced by foreign mills.

Wood flour has been known and produced in this country for some time, but the production was limited to a very few companies, and little attention has been given it as a phase in the utilization of sawdust, shavings and other milling waste until recently sponsored by the National Committee on Wood Utilization.

The uses of wood flour are numerous and diversified, ranging all the way from dolls to dynamite. New uses are constantly being developed, and it promises to become an important industrial product as well as a profitable economic solution for the disposal of material that has heretofore been frowned upon.

The wood substance of various species of trees differs very little in composition. The wood substance of hickory is not unlike that of poplar, the chief difference in the two species being in the physical structure of the material. However, there are certain infiltrations of gums and resins in some woods, and in others certain coloring, that precludes their use as wood flour for some products. Spruce, fir and pine are the chief woods used in Europe to produce the highest grades of wood flour. Similar species are represented by our true firs,

white pines and spruces. Little investigation has been undertaken regarding the suitability of American species for the manufacture of wood flour, but from casual observations the wood of maple, ash, white birch and basswood, in addition to the species now in use, should be capable of producing a good grade of wood flour, since they are entirely devoid of resin and possess the necessary light color.

GRINDING

Wood flour, as the name implies, is a finely ground or pulverized form of wood. In Europe it is ground chiefly by stone mills, which are an adaptation of the old burr stone mills used for the grinding of wheat and other grains. They consist of two large millstones, one of which is stationary while the other is connected to a vertical shaft and revolved.

The grinding stones are entirely enclosed in a wooden or steel structure, except for an intake at the top. The upper grinding stone has a sizable opening in the center through which the chipped trimmings and sawdust are conducted by means of the intake feed pipe. This material is deposited on the lower stone, which is flat. The stones grind firmly against each other, except at the inside, where the grinding surface of the upper stone is somewhat concave, forming a space for the coarser wood material when it first enters between the grinding stones. The material is thus gradually reduced and finally deposited as flour in the encasing at the periphery of the stones. Here it is drawn or blown off, and after screening is put into sacks. Steam or water in limited quantities is introduced into the mill to prevent excessive heating from friction.

Another type of mill, used chiefly for the conversion of sawdust into wood flour, is the steel burr roller mill. This consists of a series of corrugated steel rollers, each succeeding roller having teeth of increasing fineness. The rollers are closely set and revolve in opposite directions at different rates of speed.

The sawdust is passed through the series of rollers and ground to the required degree of fineness.

Among other patented devices of American manufacture is a wood pulverizer for the conversion of shavings, sawdust and hogged wood into wood flour. The material is fed through a hopper into a grinding chamber in which a high-speed grinding wheel operates. The material is pulverized by action of the grinding wheel against the sides of the chamber, which is likewise lined with a grinding surface.

One of the features of this machine is the absence of screening apparatus. A current of air is used to draw the material from the grinder. In the upper portion of the machine this current of air is allowed to expand into a somewhat larger chamber. Here the air on expanding loses part of its lifting power and the coarser particles which were held in suspension fall back into the grinding chamber. The dust-laden air is conducted on to a large settling chamber, where the wood flour is finally precipitated to the floor. In this manner the fineness of the flour is closely regulated—the slower the air current the finer the product drawn off.

There are many different products into which wood flour enters as an important constituent. Chief among them are the following:

LINOLEUM

Approximately 20,000,000 pounds of wood flour is used annually in the linoleum industry. It is employed chiefly in the manufacture of inlaid types, and in smaller proportions, mixed with cork flour, in the production of the "battle-ship" and printed linoleums.

The light, fluffy nature and consequent space-filling properties of wood flour make it particularly desirable as the filling constituent in linoleum. It is intimately mixed with cementing materials consisting chiefly of resin, linseed oil and Kauri gum. The resultant mass is of a tough, doughy consistency. This is rolled into layers, cut into the desired figures, and cemented to a burlap backing under intense pressure and heat.

Because of the necessity of imparting different colors to the various figures of

inlaid linoleum, it is essential that the filler be light in color and capable of taking pigments. Wood flour possesses these characteristics, which adds materially to its importance as one of the chief constituents in the manufacture of inlaid linoleum.

Both imported and domestic wood flour are used by the manufacturers of linoleum. The imported product is somewhat finer than the domestic, but is less uniform in its properties, and, contrary to general opinion, is not as light in color as the best grades of domestic manufacture. The extremely fine European wood flours produce a linoleum that is susceptible to a higher surface polish, although the fluffy, slightly fibrous nature of the domestic wood flour offsets the above advantage in that the minute fibres have a tendency to become felted in the cementing substance and thereby increase the tenacity and toughness of the finished product.

Another claim made for European wood flour is that it contains less resin. This, however, is not true when compared to the best domestic grades. However, for use in the linoleum industry the constancy of the resin content rather than the amount is the most important feature.

Generally speaking, domestic wood flour is preferred by the linoleum industry by reason of its uniformly light color, fluffy, slightly fibrous nature, and unvarying quality. Furthermore, the users are in closer and more intimate contact with the producers and can purchase in the quantities desired and for delivery as needed.

EXPLOSIVES

In the manufacture of explosives, wood flour has its greatest usefulness as a constituent of dynamite. Nitroglycerine in its natural state is extremely sensitive to shock and dangerous to handle, and is, therefore, barred from transportation on common carriers. However, when diluted with carbon carriers such as wood flour, and oxygen carriers such as sodium and ammonium nitrate, this sensitiveness is greatly reduced. Such mixtures are known as dynamite. A standard 40 percent "straight" dynamite contains:

Constituent	Percent
Nitroglycerin	40
Sodium Nitrate.....	44
Calcium Carbonate.....	1
Wood Pulp.....	15

Kieselguhr, a fine siliceous earth, was the original absorbing medium used in the manufacture of dynamite, but this has given way almost entirely to the use of active constituents, of which wood flour, in varying degrees of fineness, supplemented in some cases with wheat flour, corn meal and sawdust, enter as the most important materials. These constituents have a dual role to fulfill. Besides the physical absorption of the liquid nitroglycerin, there are also important combustibles and are known as active carbonaceous "dopes."

Since the force of an explosion is dependent on the sudden generation of a large volume of highly heated gases, the effectiveness of the explosive is enhanced by the use of active "dopes." Such inert materials as sand or kieselguhr do not enter into the reaction, while the active carbonaceous "dopes," such as wood flour, furnish in part the carbon and hydrogen to react with the excess oxygen of the nitroglycerin, thus approaching a complete reaction.

Miners, quarrymen and other users have learned to associate light color with fresh, high quality dynamite, and for that reason the wood flour entering into the manufacture thereof must be light in color. The situation is unfortunate, because many species of slightly colored woods could be made into equally good wood flour. The demand for light-colored dynamite is another example of custom and prejudice overruling facts.

BAKELITE

Among the newer industries demanding wood flour as a raw material is the manufacture of Bakelite. In its purest form, the substance is familiar as material from which pipe bits and sparkling amber-like beads are made.

Dr. Baekeland, the chemist who discovered the formula for producing this synthetic resin, knew that the commercial success of the substance depended on its introduction into industrial uses. However, he found the material exces-

sively brittle, which was a drawback in molding it. He set about to find a filler that would reduce the brittleness and make it more resistant to shock. After long experiments with many kinds of pulverized and fibrous fillers, he finally settled upon the use of wood flour.

Bakelite is sold under several different trade names and the list of its possible uses is too long to include here. However, some of the more common applications of the molded products are seen in radio dials, cementing material around incandescent electric bulbs, and in automobile ignition blocks, radiator caps, lever balls, etc.

OTHER USES

In the making of "oatmeal" wallpapers, wood flour is used as a surfacing. Colored wood flour is likewise used in the manufacture of velvet wallpapers. The colored material is sifted onto the paper, to which an adhesive is first applied.

Chief among the other uses of wood flour is its application as a filler in the manufacture of composite materials which vary widely in their consistency and properties. The binding materials used to unite the compound are wide in range and varying in proportion. The more important application of these synthetic compounds includes their manufacture into unbreakable dolls, brush backs, candlesticks, checkers, bowling balls, toys, graphophone records, and countless other objects.

The manifold uses of this increasingly important product should enlist the attention of every wood-using plant where sawdust or other wood substance is being discarded. Under present conditions the greatest demand is for wood flour of light color, but with its growing importance as a filler in molded articles, color will become of lesser importance.

Various types of grinding machines are being perfected for the manufacture of wood flour and there seems to be no valid reason for American manufacturers to discard their sawdust, trimmings, etc., while their European competitors are selling such material in the form of wood flour here in the United States.—*Harry H. Steidle, U. S. Department of Commerce.*

THE PINE POLE

The tremendous rate of increase in consumption of creosoted pine poles in the last six years was not due to the discovery within that period of the superiority of these poles. Creosoted pine poles had been in use for twenty-five and more years, their serviceability was becoming a matter of record when the war broke out and caused a shortage of creosote which hampered their production, but with the greater stability of the creosote market following the close of the war, and the publicity given wood preservation in general in the last few years, these poles were among the first classes of material to increase in volume. Their reputation had already been established. As a result there was an increase of 370 percent in the number of pine poles treated from 1920 to 1925. Government figures are not yet available for 1926, but manufacturers claim they will show a very large increase over the 1925 figures.

In selecting pole species the important points to consider are durability and

strength. Poles must be properly protected against decay and insects, and no part of a pole of any species if untreated is immune to damage from either of these sources. Poles must possess great strength to carry the heavy loads imposed in power and telephone lines and to withstand the strain of wind and sleet storms, if service interruptions are to be avoided. Pressure-creosoted pine poles are in splendid condition after long service and have stood up under the severest storms known in this country. Southern pine is not only one of the strongest of the commercial species grown in the United States, but, according to Government figures, possesses much greater strength than any other species used for poles. Endowed by nature with great strength, and retaining this strength by preservative treatment through its entire length, the creosoted pine pole represents the highest type of service.—*Courtesy of Wood Preserving News.*



CONCRETE MIXED WITH CRUSHED ICE OR SNOW IS CAST INTO BLOCKS, PRODUCING A VERY POROUS STRUCTURE

PAPER AND RAYON FROM CORNSTALKS

The problem of commercial utilization of cornstalks has at last been solved, after many years of research. The process of Dr. Bela Dorner, a Hungarian chemist, has been brought to the United States, tested by experts, and pronounced practicable and economical. By this process artificial silk has been produced for the first time from cornstalk pulp. The cost is low and the product has been pronounced superior to the Rayon made from wood pulp or cotton.

Plans are being prepared for manufacturing plants in the middle west corn belt to convert the waste cornstalks into chemical pulp. An advantageous site is now being sought for the initial manufacturing unit. Two locations in Illinois are under consideration.

According to the report of the engineers retained to investigate the process, the highest grade of chemical pulp can be made from cornstalks for much less than the same quality of pulp can be produced from wood or cotton. This will permit paper to be made from cornstalks on a commercial scale, which has never before been possible. The technical obstacles have been the pith and knuckle of the cornstalk, which could not be removed economically by any process heretofore invented. The Dorner process grinds up the entire stalk.

A successful commercial process means that it is possible to convert a waste material into abundant supplies of pulp for making paper, artificial silk (Rayon), motion picture films, explosives, celluloid, lacquers, artificial leather, pyralin and a host of other useful products.

It means conserving forests which are disappearing into wood pulp, and at the same time it should bring direct economic relief to the corn belt farmers, for whom a commercial use for cornstalks is a new source of income. The corn belt destroys annually more than enough cornstalks to supply the pulp requirements of the United States.

Dr. John E. Jackson, a consulting research chemist, makes for laymen the following summary:

When I was first asked to check the Dorner Process I approached it with extreme skepticism, notwithstanding the reputation of Dr. Dorner, who is head of the laboratories of the Royal Hungarian Railways and the inventor of other chemical processes which have been commercially successful. I was familiar with the many obstacles which have stood in the way of utilization of the cornstalk and the many years of research devoted to the problem. My instructions were to see whether Dr. Dorner had perfected a thoroughly practicable commercial process. I came to the conclusion that he has succeeded.

Dr. Dorner worked in closest cooperation with me for several weeks in the plant of the Barrett Company in Elizabethport, N. J., where we demonstrated his process by running twenty-five batches of cornstalks in quantities sufficient to prove that the process will operate successfully on a commercial scale. At the conclusion of the demonstration, early in March, Dr. Dorner returned to Budapest. He has worked on the development of his process for fifteen years.

No one heretofore has been able to convert the cornstalks without first removing the pith and the hard knuckle of the joints. This made the cost prohibitive. The present process uses all the cornstalk. It cuts the stalk into short lengths, washes and grinds it—joints, pith, shell, leaves and tassel—and carries it through a simple chemical treatment which involves no insurmountable mechanical problems. All of the machinery is standardized equipment. The success is due to the novelty of the method of treatment.

It requires from one and a half to two cords of wood to produce a ton of chemical pulp. Three tons of cornstalks will produce a ton of the highest grade chemical pulp. The cost of gathering three tons of stalks in the corn belt, with a fair price to the farmer, will be well under the present cost of two cords of pulpwood.

Cornstalks are now largely waste. In parts of the corn belt it is the practice

to burn the stalks as the cheapest method of getting rid of them. In districts attacked by the corn borer, the Government is paying the cost of burning stalks. The Government's program will be assisted by converting the cornstalks into pulp.

The supply of cornstalks renews itself every year within easy transportation distance of the factory, and there will be no frozen investment in timber lands while the supply of raw material is growing.

Dr. Jackson further stated that he had supervised the spinning, twisting, dyeing and weaving of artificial silk from the cornstalk pulp produced in the demonstration manufacturing at Elizabethport. He said the silk has been made by all three of the major processes, and that exhaustive tests have shown it to be superior to the silk made from wood pulp and equal to and in some respects better than the silk produced from cotton.

Ordinary chemical pulp contains about seventy-five to eighty percent of pure cellulose. In ordinary papermaking the purity of the pulp is not of primary importance. But in making artificial silk, lacquers, explosives, celluloids and other "chemical cellulose products" it is of the utmost importance that the cellulose content be as high as possible. For this reason cotton has been the principal base from which the various "chemical cellulose products" have been made. Only recently have some of the pulp companies been specializing in the manufacture of a limited quantity of chemical wood pulp attaining as high as ninety to ninety-five percent cellulose content.

Chemical pulp from cornstalks has now been made up to 99.3 percent pure cellulose content, and in commercial operation it will be produced from ninety-five to ninety-nine percent pure.

Paper was made from cornstalk pulp and it has been pronounced superior to that made from good grades of chemical wood pulp. The fibres of the cornstalk pulp produced are not longer than the fibres from wood, but their structure is unique in that the ends of the fibres have a fish-hook effect which in-

tertwines to produce a tough and tenacious material. The finer fibre from the cornstalk can be used in paper manufacture to fill in and bind the coarser wood fibres in a mixture which becomes compact, smoother and of greater tensile strength than papers made from ordinary pulp.

Cornstalk pulp has also been made into transparent paper such as is used to wrap candy boxes, known as "Cellophane," and tests show superior properties over the same product from cotton.

Tests are now being conducted to determine further uses for the cornstalk product, and ultimately the subject of by-product recovery will be further developed.

By-products of this process can be used in the manufacture of alcohol, cattle feed, butanol, furfural, lactic acid, etc. It is believed that these by-products will prove to be a source of considerable additional revenue.

Further conclusions of the engineers are as follows:

The manufacture of pulp from cornstalks by the Dorner Process should, under proper management, prove to be a successful industry. An excellent quality of pulp having a high alpha cellulose content is produced and it should satisfy a real need in the pulp industry.

The large corn crops of the corn belt in the middle west assure a continuous and plentiful supply of raw material. This material is now largely wasted and, in some instances, is a constant source of damage to future crops by soil infection. Pulp mills can be strategically located throughout the corn belt so that the handling of the stalks from field to mill can be easily and economically accomplished. Mills so located would have the distinct advantage of a close and continuous source of supply of raw material due to the fact that this material results from a yearly crop. In the wood pulp industry the source of the raw material becomes more distant each year as the timber is used up, which causes a resultant increase in the cost of production. It is not uncommon for mills to obtain pulp wood at points 500 to 1,000 miles distant from plants.—*C. B. Roberts.*

OIL-BURNING FURNACES

A SURVEY OF PROGRESS

It is but human to want the greatest comfort in one's home, and so the problem of heating the home in an efficient and healthful manner is one that occupies a great deal of attention. The market has recently been flooded with numerous types of oil-burning devices that are designed to be used in standard coal-burning furnaces. The interest in these has been so great that we have made an extensive survey of the situation and this has led to the conclusions that are put forth in the accompanying article. In the selection of a home-heating plant of the oil-burning type, the average person should not feel competent to judge for himself as to the one to buy. This important detail should be left to some one who is constantly in touch with the oil-burner manufacturing field. If any reader who desires to install a new heating system will follow this article, we are quite sure that he will have little or no trouble with an oil-burning plant.

The difficulties of the owner of a coal-burning furnace are many. It is not only necessary to purchase a large quantity of fuel, usually at a time when the household finances are rather low, but it is also necessary to periodically transport this fuel from the storage bin to the furnace, by hand, and to otherwise take care of the heater. The shaking down and removal of ashes is a dusty job and one that the average house owner would be only too glad to get away from. These, and other objections to the use of coal as a house-heating fuel have led many to find a way out of the difficulty.

At the present day, house heating by means of oil seems to be the solution to the problem. Oil holds many advantages. It is easy to obtain and to store and a well designed and properly constructed oil burner will operate throughout an entire cold season without any attention whatsoever on the part of the owner.

HOW TO SELECT AN OIL BURNER

When the house owner is considering the installation of some new type of heater in his present coal-burning furnace, there are two questions that are uppermost in his mind. The first is, "How does the cost of oil compare with coal?" The second question is "What is the best oil-heating device to install?"

A consideration of the cost of oil burners and of their installations as well as of the accessories necessary, brings us to the conclusion that at the present time, there is but little saving in cash that can be effected. However, there are many advantages on the side of the oil burner that would tend to overcome even an increased cost.

A fair comparison of the cost of a good grade of fuel oil as against coal can be obtained if we consider that 100 to 125 gallons, efficiently burned, will provide the same amount of heat as one ton of a good grade of hard coal. At ten cents per gallon or less, according to the market, it is obvious that there will be an actual saving of from twenty-five to forty percent in favor of the oil. There is, however, the additional cost of the pilot light, plus that of the electric current for the automatic control and motor. For the pilot light, the cost of gas will average 75 cents to \$1.25 per month, and for electricity, \$1.25 to \$2.00 per month, making a total of from \$2.00 to \$3.25 per month. Moreover, heat will probably be used at least a month longer each year because of the automatic functioning of an oil system on chilly mornings and evenings, when building a coal fire would be too much trouble. It is this last consideration, however, that makes an oil-heated furnace desirable, for it provides an even temperature in the house at all times, independent of human effort.

The cost of a good installation, including a storage tank of about 275 gallons capacity, runs from 350 to 550

dollars or even higher. Although there are cheaper devices advertised, it is usually found that either they are not as dependable, or that the cost of the extras which are not included in the advertised price for the mechanism, when totaled, will raise the complete cost practically up to these figures.

It is obviously impossible for us to advise each individual reader as to the type of oil-heating device that is to be installed. We have illustrated on these



ALL BUT THE CARBURETOR IS IN THE
ASH-PIT

pages several types of oil burners that can be installed in standard coal-burning furnaces. Probably the best thing for a furnace owner to do in order to determine the type of oil heater that he should buy, is to communicate with the manufacturer of the coal-burning furnace that he has on hand. They will probably be able to tell him just what type of oil burner will be most satisfactory for use in connection with that heater. Another good plan is to get in touch with a company of heating

engineers. They can act in the capacity of consultants and also as an intermediary between the consumer and oil-burner manufacturer. This latter course will not be any more expensive in the end because the company of heating engineers will get their commission from the manufacturer of the oil burner that you purchase. Furthermore, their experience with all types of coal-burning furnaces and with the installation of oil heaters therein will enable them to advise the consumer in the most intelligent manner possible.

In general, there are two types of oil burners on the market today. In one type, the oil is thoroughly atomized and mixed with air. This process is carried through by means of an electrically driven pump. The other general type uses gravity feed. It is interesting to know that the United States Department of Agriculture has carried on numerous tests with these two types of furnaces and the results of these are expressed in the following paragraphs, quoted from a recent report of that department.

GOOD COMBUSTION ESSENTIAL

"The tests conducted show that the atomizing type of burner is higher in efficiency and has less tendency to soot than the gravity type. Fuel oil will not burn readily when a flame is applied to its surface and hence the oil must be prepared for combustion. In the gravity-feed type, some device such as a hot plate is necessary for volatilizing the oil. In some types, the plate is heated to get the fire started after which the heat of the oil burning on the plate is relied upon to keep it hot.

"Air is generally brought into the furnace by the natural draft produced by the chimney. Ingenious methods have been used to induce an intimate mingling of this air with the vaporized fuel. In general, good combustion is not secured by this means. While the principle seems simple enough, the fuel and air are not mixed with sufficient thoroughness to produce a good clean flame. In the cheapest burners of this class, the burner is started and controlled by hand.

"The atomizing type of burner includes the spray type and those which

break up the oil by forcing it under pressure through a small opening, air being supplied to the flame by a blower or pump arranged so that it can be regulated. The spray type of burner consists principally of an air and oil nozzle arranged so that air from a motor-driven compressor blows directly over the oil nozzle, creating a partial vacuum. This draws from the oil supply a finely divided oil spray in somewhat the same manner as gas is supplied to the cylinders by the carburetor of an automobile. The rate of feed is controlled by the air pressure and nozzle opening. Automatic control with a thermostat is generally used.

"For the atomizing type, gas or electricity, or possibly both, are required for ignition, and electricity is used to operate the motor which drives the blower and oil-pump unit.

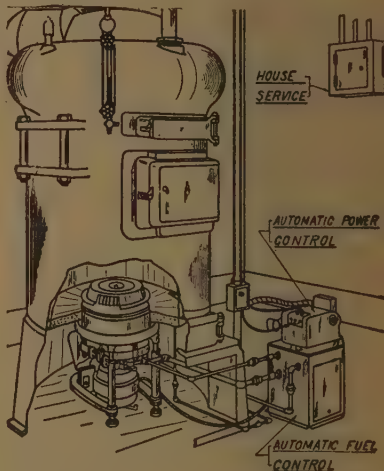
"Gravity-type burners are installed at a cost as low as thirty dollars, but in addition to the objection of sooting and inefficient combustion, they require a high-grade fuel costing more per gallon and containing fewer heat units per gallon than lower grade oils."

CLEANLINESS AN ATTRACTIVE FEATURE

After oil heating has been installed, the furnace man—be he owner or hired—is done away with and the idiosyncrasies due to individual methods of firing are eliminated. It is only necessary to start the oil heater in the fall, to set the automatic temperature regulator at the desired point and forget about the furnace for the rest of the season.

The fuel oil that is employed in connection with an oil burner is stored in a tank buried in the ground outside of the house. A filler pipe for this tank extends out to the curb. In order to get a good idea of the comparison between coal and oil-burning facilities, form the two mental pictures described in the following sentences. A truck-load of coal is driven up to the side of a house, the coal chute put in position and bag after bag of coal rattles down the chute. This nerve-racking noise continues for possibly half an hour. After the coal man drives away, small pieces of coal are found within a radius of five or ten feet around the window or

other opening through which the coal was introduced. These must all be picked up in order to keep the yard looking neat. After the furnace has been in operation for some time, the ash pile grows steadily higher and higher. An ash man comes and takes it away. He charges for his labor. The dust that is necessarily stirred up during his work is most annoying as it will sift into the house and settle everywhere that it is not wanted.



EMULSIFIED OIL IS THROWN FROM A SPINNING DISK

The other picture is far simpler. An oil-tank truck draws up to the curb and places a delivery pipe in the tube that connects with the home oil-tank. In a few moments, a hundred or more gallons of oil have been delivered without noise, dirt or trouble and the tank drives away. This is the last that is seen of the fuel, either in its original form or in the form of a burned residue. There are no ashes to be removed.

In one of the types of burners that we illustrate, an emulsified mixture of air and oil is shot downward toward a surface of heated bricks that have been placed over the old grate and around the fire box. The reflected heat from



NO SPECIAL SETTING REQUIRED FOR THIS BURNER

these bricks reacts to produce more efficient combustion. With this type of burner, the bricks can be removed from the fire pit and the furnace used for coal burning in case this should be necessary, due to a temporary failure of the electrical supply to the burner mechanism.

Another type shown is that in which practically the entire mechanism is set up in the ash pit with the ordinary coal grates removed. Oil mixed with air is thrown from revolving or stationary peripheral orifices through breakers, becomes volatilized and is burned like a gas. The mechanical mixture of oil and air is sometimes agitated further and projected toward a hot iron surface or a glowing refractory substance which aids more complete combustion. A pilot light fires the oil and a thermostat responsive to the heat of the rooms controls the speed of the actuating motor.

A combination of the two types of burners described is also illustrated. In this very efficient unit, the actuating mechanism is placed outside of the heat-

er and a burner in the pit causes the combustion of the oil. This particular system does away with the necessity of having brick linings or specially constructed refractory baffles.

There is one other feature to be found in connection with oil heating that we must not fail to stress. It is one that will appeal to all as it enables the home owner to obtain more space for living or recreational purposes. When a coal-burning furnace is used, a large part of the cellar is taken up by the coal storage bins. The ash receptacles that are a necessary part of the furnace equipment also take up space. The very nature of the coal-burning furnace eliminates the value of the remainder of the cellar for anything else than for the storage of materials that are not damaged by dust and dirt.

All this is not the case when oil heating is used. Then the heater and its apparatus takes up only a very small part of the cellar. The remainder at once becomes available for other purposes and the average home owner, after

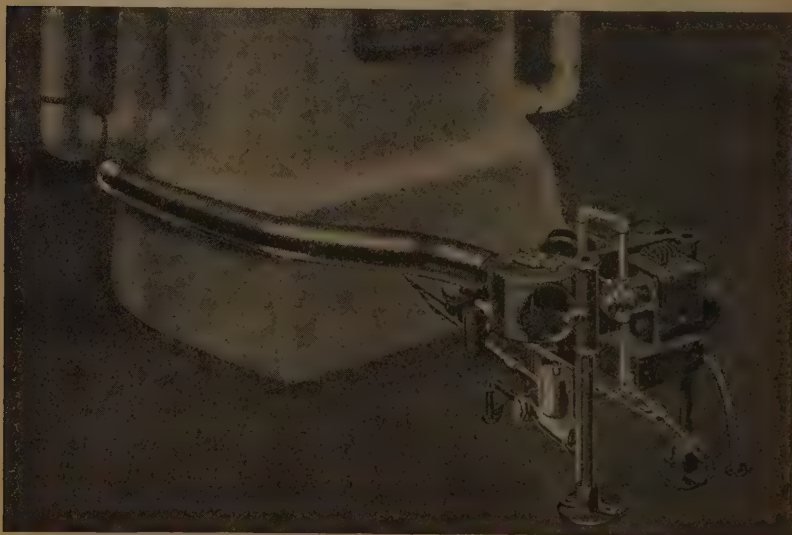
installing oil heat, usually takes advantage of this at once. It is not infrequent to find that a billiard or card room has been built in the place that formerly was occupied by the coal bins. A very convenient laundry also can be located in the cellar. Play rooms for the children and other space-saving ideas will present themselves.

EVEN TEMPERATURE PROMOTES HEALTH

It must not be thought that the construction of such rooms in a basement will be highly expensive. The contrary is true. Plaster board can be used and the walls can be papered or painted at a low cost. In many cases, the man of the family will take delight in the work entailed in building these rooms.

With coal-burning furnaces of any kind, regardless of whether they be of the hot air, hot water or steam type,

the fumes from the burning coal are bound to get into the house and to cause a disagreeable settlement of dust. This is not only bad from an esthetic standpoint, but the effects of the fumes on health are detrimental. With oil heating, all of this is done away with. The house is always heated at an even temperature due to the thermostatic regulation possible and in this manner, health is again promoted. It has been said by those who have never investigated oil furnaces to any great extent, that oil burners are noisy in operation. This was true of some of the original types, but recent improvements have done away with this and other deficiencies, and the public, today, can purchase well-designed oil-burners that will operate with the greatest efficiency and with the least amount of trouble and attention.—*The Editor.*



A PART OF THE STACK GASES IS MIXED WITH THE FUEL

ANTI-KNOCK MOTOR FUELS

During the first forty years of the American petroleum industry the chief product was kerosene, and the price of crude oil was largely determined by the kerosene content of the crude and the market for this commodity. The advent of the automobile made gasoline the chief factor in determining the price of crude oil. A further change was brought about by the introduction of cracking processes, by which components of the crude having too high boiling points for motor fuel can be broken down under the action of heat into lower boiling materials known as cracked gasoline.

Not only the quantity of gasoline originally present in the crude—technically known as straight run gasoline—but the additional amount obtained by cracking had then to be taken into account in adjusting prices for the crude and the other petroleum products. Today another factor must be considered, namely, the anti-knock value of both the straight run and cracked gasoline. In the light of the above a price revision may be expected in favor of such low gravity crudes as Smackover, from which high quality anti-knock gasolines can be produced by cracking.

It was only a few years ago that the gasoline of highest rating and price was the straight run material from a paraffin base crude such as Pennsylvania. It was sweet to smell, water-white in color and of high test when measured on the Baumé gravity scale, and the specifications for all gasolines were written to cover these properties. One still hears occasionally of this "good," "high test" gasoline. However, in the light of present knowledge, it appears that it was "high test" by definition only. A gasoline with a low Baumé gravity is now known to be better than one with a high test, all other properties, including volatility, being the same. Today the anti-knock quality of a gasoline rather than color, odor, gravity and the like is the true measuring stick of the value of a motor fuel, as this property more than any other governs its performance in the engine,

Straight run gasolines from paraffin crudes are the worst knockers. Gasolines from asphaltic base crudes, such as Californian and Russian, with their much lower Baumé test, have excellent anti-knock properties. Gasolines from other crudes, such as Mid-Continent and Gulf Coast, are intermediate between these two in anti-knock quality. Cracked or synthetic gasolines, with their poor color and smell, always have a better anti-knock value than straight run gasolines from the same crude.

BLENDING MATERIALS

The anti-knock value of gasoline can be improved by the addition of certain materials. It has been known for some time that benzol—a product of coal gas and coke manufacture—is effective when used for this purpose. However, if the total supply of benzol were available, less than 5 percent of the gasoline consumed in this country could be so blended. T. Midgley, Jr., and T. A. Boyd of the General Motors Research Laboratory have shown that small amounts of certain materials, such as aniline or tetraethyl lead, have a profound effect on the knocking tendency, and large quantities of gasoline containing tetraethyl lead are now being sold.

Another type of cracking process known as vapor phase cracking is now coming into favor as a method of preparing a cracked gasoline for blending which is the equal of benzol in its anti-knock effect. At least two important companies are soon to start up large installations of vapor phase cracking units, despite the somewhat higher cost of production of this gasoline over that produced by the several commercialized pressure still or liquid phase cracking processes.

Anti-knock gasoline can be prepared in many cases by the refiner without the addition of anti-knock dopes or benzol, by a careful choice of crudes and methods of cracking and treating. Even if the anti-knock value of such a composite gasoline does not come up to the accepted standard, the effort is not

wasted, as much less of the relatively expensive benzol or dope is required.

ENGINE EFFICIENCIES

The energy in a gallon of gasoline is equivalent to 93,360,000 foot pounds of work, that is, it is sufficient to raise vertically this many pounds one foot. When this figure is multiplied by 12,500,000,000, the approximate number of gallons of gasoline consumed in the United States last year, the total is beyond comprehension. Eighteen Niagaras, completely utilized, operating continuously throughout the year, could barely furnish the same power. Under present conditions only about 5 percent of the total energy in the gasoline is used for the actual effort of pushing the car along the road. Of the 95 percent lost, more than one-third goes into the cooling water, more than another third is blown out with the exhaust gases, and the rest is accounted for by various friction and radiation losses. It will readily be seen that the efficiency of the gasoline engine can be increased materially by making a relatively slight reduction in these losses.

HIGH COMPRESSION ENGINES

One of the methods still available to the automotive engineer for improving engine efficiency is to increase the engine compression, that is, the pressure to which the fuel-air mixture is compressed before it is exploded. A high compression engine requires a special type of fuel. If ordinary gasoline is burned in such an engine violent knocking will result. This knocking is generally considered to be the result of a too rapid combustion of a part of the explosion mixture in the engine cylinder. It corresponds to a sharp sledge hammer blow on top of the piston instead of a long, steady push. Under knocking conditions there is a loss of power, overheating of the motor, an un-

due amount of wear on bearings, cylinder distortion, and other accompanying troubles.

Now that anti-knock gasolines are becoming available throughout the land, automobile manufacturers are preparing, and in some cases have already begun, to raise the compression with a resulting increase in fuel economy to the motorist and a decrease in engine size and weight for a given power production.

PRACTICAL ADVANTAGES

In the present-day engine of relatively low compression ratio an increase in mileage is not necessarily noted when an anti-knock gasoline is used. The chief benefit accruing is a greater flexibility in operation—a luxury factor—and the elimination of knocking on heavy pulls uphill or through sand or like conditions. Fuels of intermediate anti-knock value are capable of effecting such results in the present motor. High compressions require fuel of high anti-knock value.

Recent tests by a leading automobile manufacturer indicate that a small increase in engine compression over present design, together with other adjustments, such as gear ratio in the differential and the use of a gasoline of high anti-knock value, will show a 25 percent increase in mileage. It has been estimated that an increase of 40 percent is possible by this means.

Today the public is being asked to pay a 3-cent premium for an anti-knock gasoline. Tomorrow there will be an anti-knock specification for gasoline, since most cars will then require it, and the price at which such gasolines will sell will be the regular price. Gasolines which are not up to the anti-knock standard will be sold at a lower price.—*Courtesy of Industrial Bulletin, Arthur D. Little, Inc.*

COAL CARBONIZATION

LOW TEMPERATURE PROCESS

From time immemorial, the smoke nuisance has been the ever-present incubus of the burning of coal, the world's most abundant and otherwise most perfect fuel.

In 1550, Queen Elizabeth prohibited the burning of coal in London during the Parliamentary season for fear "the health of the knights of the shires might suffer during their stay in the metropolis." Yet through the centuries, thousands of lives and billions of dollars worth of damage to clothes, property and vegetation has been the toll of this smoke. Coal has made possible America's marvelous industrial era of the past three decades and now, paradoxically, our cities are wailing lustily for smoke abatement and with equal vociferation demanding well-laundered workshops.

WHAT IS "L. T. C."

It was recognized early that smoke was but an indication of the partial and inefficient combustion of certain gaseous constituents of coal, and that the best way to eliminate or minimize it was to separate the solid from the gaseous components, burning each subsequently in furnaces particularly adapted for their use. Dr. H. C. Porter, in his valuable treatise on smoke, defined coal carbonization as "a process of modifying a crude, raw fuel into better fuels; of extracting valuable by-products—ammonia, light oils and tar—before they are destroyed in the burning, of converting the raw, smoke-producing, inefficiently handled coal into a clean and smokeless gas or coke, efficient in use and in distribution."

One cannot review the history of coal carbonization without being impressed with the fact that the initial and fundamental idea has been paramount in promoting the comfort, health and economic betterment of the public by substituting some more efficient medium than raw coal for the generation of heat.

Nevertheless, the entire way behind us is sadly smudged over with soot, and we are all eager to know whether clear skies and sunshine are just ahead.

What, then, is "low-temperature carbonization" and why is it so called? A little over one hundred years ago, Murdock of England and Lebon of France established the gas industries of their respective centuries. The first gas companies were established in the United States at Baltimore in 1819, at Boston in 1822 in New York in 1825. Yet it was not until the close of the Nineteenth Century that any notable advances over the initial discovery of the process of carbonization by Murdock and Lebon were made. For substantially seventy-five years, the carbonization of coal was carried on in the same way and at the same high temperature of from 950 to 1,200 degrees, Centigrade, or 1,750 to 2,100 degrees, Fahrenheit, as at the outset, with small attention devoted to further modification or improvement.

About this time, scientists began to reason that as there were many ways of cooking beef to suit different tastes, so there might be correspondingly different ways of cooking coal the better to suit differing economic needs. In fact, except for the temperatures used, the processes apparently were strikingly similar. Like steak, coal can be grilled over a fire—either rare, medium or well-done. You can roast either beef or coal in an oven. You can boil them over a fire and make soup of them. By so doing with the beef, you can convert what originally appeared to be a solid into three benefited components—a solid food in the form of a "roast," a liquid food as "soup" or "gravy," and a gas, that is to say, an aroma, which pervades the home to stimulate the appetite!

Hitherto, in carbonizing coal, we had cooked it only "well done," and for each ton of coal we had obtained thereby, of benefited solid fuel, sixty to

seventy percent; of viscous liquid tar, about ten to twelve gallons; of city gas, about 11,000 to 12,000 cubic feet, and of ammonium sulphate (a fertilizer base), about twenty-five to thirty pounds.

COOKING COAL "RARE" OR "WELL-DONE"

About 1890, Mr. T. Parker in England conceived the idea of cooking coal "rare" at from 450 to 600 degrees, Centigrade, or 850 to 1,100 degrees, Fahrenheit, as well as doing this by a continuous process rather than by the intermittent charging and discharging of the high-temperature coke ovens, whose temperatures did not permit the intro-

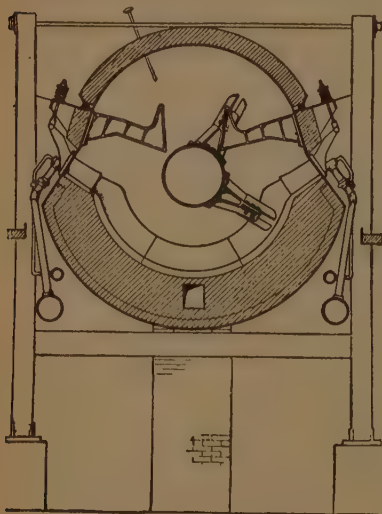
promise to a modern civilization whose cornerstone is fuel converted into heat and power. Last year David Brownlie of London, a noted British authority, advised the author that in the preparation of his contemplated book on "low-temperature carbonization" he had discovered to date over 120 processes, and something like eight or nine hundred patents. By these methods have been produced from each ton of raw coal, of solid, smokeless fuel (generally called "semi-coke," superior as a domestic fuel to high-temperature coke), about seventy percent; liquid tar oils, free-flowing and not much heavier than water, from twenty to thirty gallons; gas, almost twice as rich as city gas in its heating value, about 4,000 to 5,000 cubic feet; and ammonium sulphate, some ten to fifteen pounds.

Apparatus for the low-temperature carbonization or "distillation" of coal may be divided into two classes, the first heated externally, heat being transmitted from outside the oven or "retort" through a wall, the second heated internally, carbonization being effected directly by hot gases passing through the charge of coal.

AN AMERICAN INSTALLATION

The apparatus for external heating may be further subdivided into stationary and rotary retorts. The stationary retorts may be of the shaft type, the horizontal type, or of the tunnel kiln type, as will be described later. The coal tree on page 175 shows in somewhat greater detail the yields, both primary and secondary, of the Thyssen (German) rotary retort as given the author by the former chief engineer of the Thyssen company.

Externally Heated Vertical Retorts: The original Parker "Coalite" process utilized the principle of an externally heated vertical retort. An installation of two batteries of thirty-two vertical retorts, each battery designed to carbonize fifty tons per twenty-four hours, has been installed at Barugh, Barnsley, in Yorkshire. Each retort consists of an iron casting in one piece, containing twelve vertical tubes tapering from four and one-half inches internal



THE MCINTIRE RETORT

duction of moving parts without prohibitive maintenance cost. Furthermore, many weakly-coking coals might be coked which, with the high-temperature methods, were unutilizable. Being done at much lower temperatures than the previously known process, such coking methods became generically known as "low-temperature carbonization."

Out of the Parker patents has grown up a technique of continually increasing

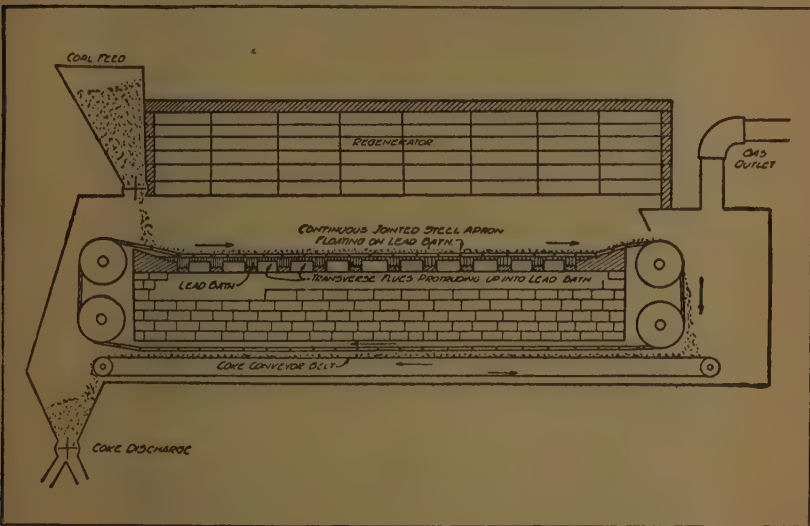
diameter at the top to five and one-half inches internal diameter at the bottom, and nine feet long. The structure might be likened to a vertical water-tube boiler, with coal instead of water filling the tubes, the tubes tapering out toward the bottom. The retorts are heated by burning a mixture of low-temperature gas and producer gas in the combustion chamber surrounding the retorts.

Externally Heated Horizontal Retorts: Of the externally heated retorts of the horizontal type, probably the most in-

used as a domestic or producer fuel, or screened out and fired in pulverized fuel furnaces.

Externally Heated Tunnel Kiln Type Retorts: Representative of the tunnel kiln type of retort are the well-known Ford installations of the Piron retort, one of which is shown below.

In this example, the coal is conveyed through a closed retort on an iron conveyor which floats across the surface of a molten lead bath. The heat of the lead devolatilizes the coal, and the coke



THE PIRON RETORT AT THE FORD PLANT

teresting in America is the McIntire retort shown on page 170. The coal is fed into one end and the semi-coke is discharged from the other. As will be clearly seen in the illustration, a series of paddles carried on a central rotating shaft moves the coal along the bottom of the retort, agitating it at the same time. The heating is done along the bottom surface over which the coal is being conducted, and the resulting coke is discharged in small pieces, due to the agitation. This fine coke can be briquetted with a pitch binder, recarbonized and

is carried out and discharged from the conveyor belt. It is claimed that a layer of coal one-half inch thick is completely carbonized in five minutes at a temperature of 650 degrees, Centigrade. The fire-brick retort is about fifty feet long. Gas is the source of heat for maintaining the lead bath at the required temperatures. The products of combustion pass through narrow passages under the bath, into the checker brick regenerator settings overhead. The semi-coke delivered is not in a suitable form for use as a domestic fuel, it being the inten-

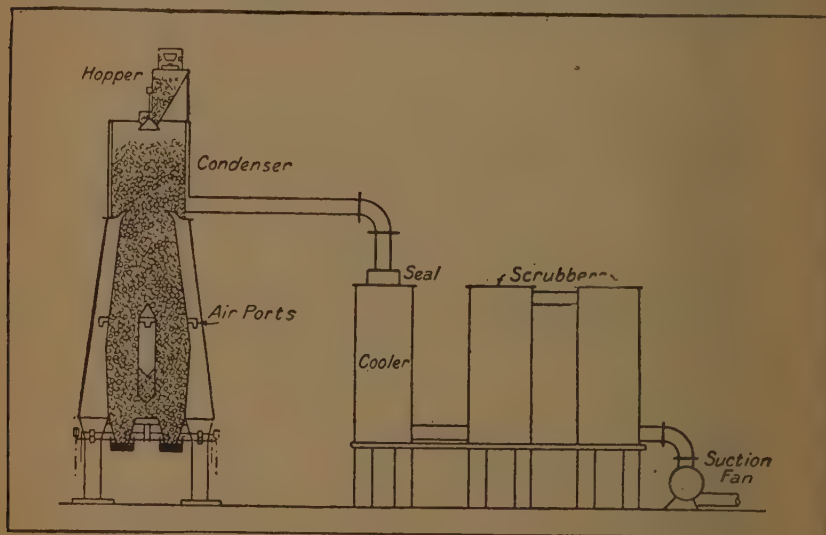
tion to pulverize the greater portion of it for steam-raising purposes.

Externally Heated Rotary Retorts: Rotary retorts have found special favor in Germany and to some extent in England. The first rotary retorts of really large dimensions were designed by Thyssen and Company at Mulheim-am-Ruhr, a few years ago. At present there is a plant of 100 tons per day throughput at Thyssen and Company's works, another at the Hamburg Gas Works, and the two units at the Prince Bismarck

being heavily lagged against heat losses. The distillation gases together with the tar vapors leave the drum at the same end as the semi-coke.

WHAT IT ALL MEANS

Internal Heating: In general, four heating media have been attempted in internally heated retorts—superheated steam, hot producer gas, hot coke-oven gas and hot flue gases. There seems little doubt that steam is the most suitable direct heat carrier because it can



McLAURIN RETORTS ARE IN REGULAR PRODUCTION

Colliery, shown on page 173, which produce over thirty different commercial by-products.

The iron drums of these retorts are built in one piece seventy-eight and one-half feet long by eight and one-half feet in diameter. The coal is fed into the rotating tube at one end and is carried through the length of the tube in two hours by means of helical screw lifters riveted to the drum, dropping at the other end in the form of semi-coke. The iron drum runs in a chamber which is fired with producer gas, the chamber

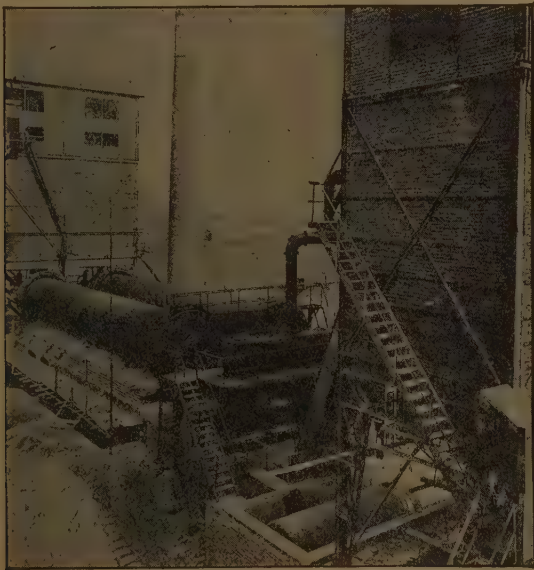
be separated from the products of distillation by suitable cooling, so that these products are obtained in an undiluted form. Such a process, however, gives little commercial promise and the operation is very expensive for complete tar recovery. It is not sufficient merely to cool the large amount of steam necessary to 100 degrees, Centigrade; the steam must be condensed to water to make the extraction of benzine possible. This involves further steam raising, a combination which even with good heat exchange means a large expenditure of

fuel and cooling water. Owing to their improbability of commercial success, the several processes employing this method will not be described.

Hot Producer Gas as a Heating Medium: McLaurin in Scotland effects carbonization by means of hot generator gas instead of superheated steam, as shown on page 172.

The McLaurin retort is essentially a by-product recovery gas producer in

the same level. The coke is cooled in the zone below the air port, steam being injected at the discharge doors. A part of this steam ascending through the coke becomes heated and partly decomposed into water gas, thence passing upward and mixing with the producer gas formed in the combustion zone. The raw coal is discharged from an elevated hopper through a bell into the top of a cylindrical steel tank eight feet in



THE THYSSSEN ROTARY RETORT

which part of the semi-coke is burned to producer gas, the sensible heat of which carbonizes the descending charge of coal. The experimental producer at Grangemouth, Scotland, is of square cross-section, about forty-five feet high by eight feet wide at the widest part. The air-blast is introduced about twelve feet above the discharge doors, through a large number of narrow ports in opposite side-walls, and also by similar ports in a dividing wall which is carried across the center of the retort at

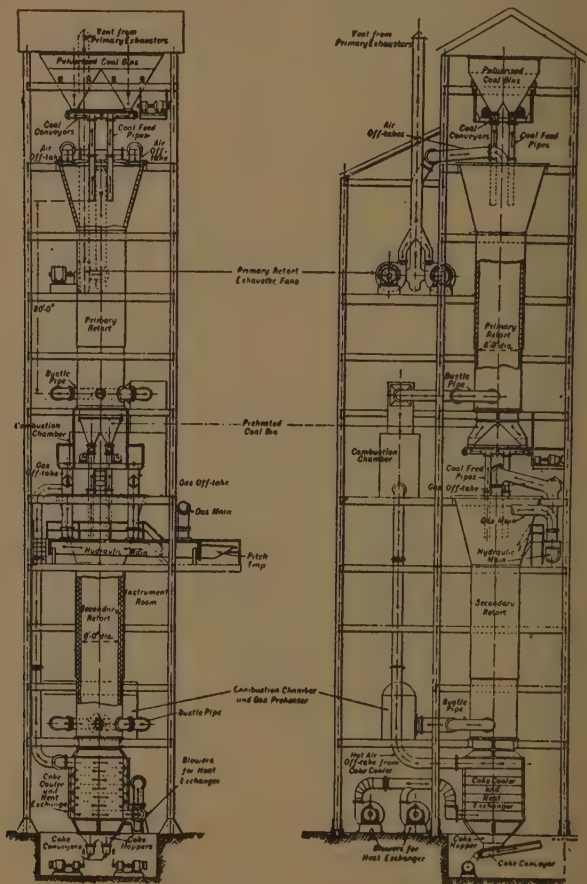
diameter by ten feet high, resting on the brick work at the top of the retort.

This tank serves as a condenser for the oils and tars which drain down the side of an inner steel cylinder which dips into the well formed by a dished flange at the bottom of the tank. From the annular space between the tank and the cylinder, the gases are led off to tower coolers and scrubbers. The plant is continuous in operation and a retort of the dimensions given will hold about thirty tons of coal. A 100-ton-plant em-

ploying this process has recently been installed at the Dalmarnock Gas Works at Glasgow, Scotland.

Hot Coke-Oven Gas as a Heating Medium: In England, Sutcliffe and

ture of the coke which they then make from these briquettes. Through the hardness and strength thus obtained, they are able to put enormous tonnages into large perforated cylinders mounted



THE MCEWAN-RUNGE VERTICAL RETORT

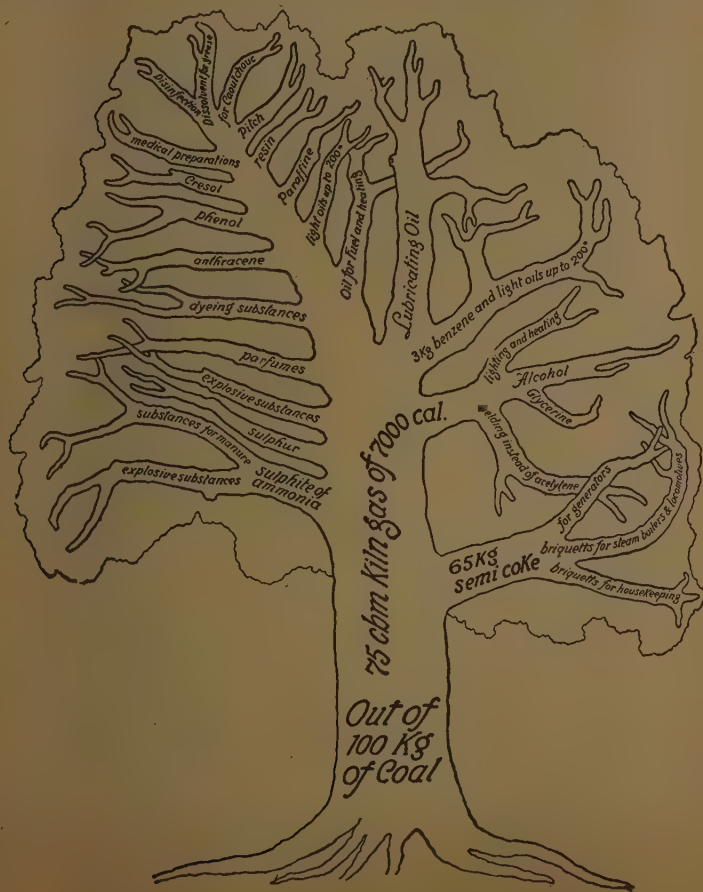
Evans blend coal, rich in gas, with lean or oxidized coals, briquetting the mixture at high pressure without the addition of a binder. By this means they are able to improve the physical struc-

axially in a vertical retort. Through this retort they circulate hot coal gas. This gas is continually reheated in two regenerators, one of which gives up its heat to the return gas while the other

is being brought up to temperature again by the combustion of the surplus carbonization gas, with the usual arrangement for changing over.

Carbonization by Means of Flue (or Re-Run) Gases: Undoubtedly, the most interesting recent development to American operators is the announcement of the installation of a 200-ton McEwan-

Runge commercial-scale experimental retort at the plant of the Milwaukee Electric Railway and Light Company. The operation of this plant is shown on page 174. It utilizes the principle of carbonization of pulverized coal in suspension by means of flue (or re-run) gases. The powdered coal is dropped into an internally heated tower where it



THE COAL TREE

comes in contact with an upward current of hot, inert gas. The extremely large surface of the finely divided coal particles insures a rapid transfer of heat so that distillation is effected during the time the fuel falls from the top to the bottom of the tower, a distance of about thirty feet.

WHAT ITS ADVENT WILL MEAN

When using coals having a tendency to agglomerate, advantage is taken of the fact that by preheating the coal to an average temperature of 365 degrees, Centigrade, the coking tendencies of the particles are destroyed. It is then passed through another tower, immediately beneath the first one, where the balance of the volatile matter is distilled by passage through a counter-current flow of gas at an average temperature of 565 degrees, Centigrade. The gases and vapors are then carried off to the scrubbing and cleaning apparatus and the pulverized semi-coke is conveyed from the bottom, to be burned under boilers in pulverized form.

What, then, is the significance and the future of low-temperature carbonization? The reader will have observed from the previous discussion that the expenditure of thirty-six years of continuous scientific effort and many millions of dollars in research have resulted in developments which bring us today to the threshold of the commercial achievement of an important new method of serving society. With its

advent, Europe will be less and less dependent, as at present, on overseas supplies of oil and motor fuels. America will regard with less dismay the fact that her domestic supply of oil, recoverable by present methods, if expended at the 1925 rate, will last but a decade. More and more will the smoke problem of our cities be solved to the benefit of the community's health, comfort and financial profit. A new and important source of land fertilization will contribute toward larger and better crops for the farmer.

How soon we will commence to feel this in a large way, one hesitates to predict. An auspicious start has been made. Engineers, scientists and financiers are redoubling their efforts to expedite its larger application. If the present rate of progress continues, another decade should see smokeless low-temperature coke, oils, gas and fertilizer widely available in Europe and in the larger American cities, particularly those of the middle west where coking coals must be hauled hundreds of miles, frequently on tracks laid immediately over enormous deposits of non-coking or weakly-coking middle-western coals.

Meanwhile, as in the history of other major engineering developments, wily promoters with inadequately conceived ideas will profit hugely to the detriment of the gullible public, while a few far-sighted financiers will ally themselves with competent engineers, and merit the enormous profits justly due successful pioneers.—*H. W. Brooks.*

WINDIEST PLACE IN AMERICA

The summit of Mount Washington, in northern New Hampshire, is one of the windiest places in America. Over forty years ago the Signal Service of the U. S. Army maintained a weather observatory there for a short time. On January 3, 1883, the wind there increased to a violent hurricane, and while a velocity of 152 miles per hour was being registered by the anemometer, the latter instrument was broken off at the dial, and it was found impossible to replace the instrument during the violence of the storm. On February 27, 1886, the mean hourly wind velocity for twenty-

four hours was 111 miles. In January, 1878, the extraordinary velocity of 186 miles per hour occurred. These high velocities were indicated by an ordinary Robinson cup-anemometer, which indicates velocities about 20 percent too high. But even when the extreme of 186 is corrected to 140 miles per hour true velocity, the rate is obviously very high. But gusts of even higher velocity are believed to persist for a second or two. It requires all a strong man's strength to enable him to stand on his feet in a wind blowing at the rate of 100 miles per hour.—*Tycos-Rochester.*

MOTION PICTURE FILMS

WHO INVENTED THEM?

The opening of the Paramount Theatre last fall with its bronze plaque in honor of Thomas A. Edison, has revived interest in the question of the inventor of motion picture film. From J. R. Cominsky of Rochester, N. Y., has come evidence to show that George Eastman, Chairman of the Board of Directors of the Eastman Kodak Co., was really responsible for the film as it is used today, and not Thomas A. Edison, as was announced at the time of the gala opening of the new theatre last November.

From the files of *The World* another party is brought in, the late Rev. Hannibal B. Goodwin, rector of the Episcopalian House of Prayer of Newark, N. J.

On March 10, 1914, Judge Hazel handed down a decision in the United States Circuit Court of Appeals in favor of Dr. Goodwin against the Eastman Kodak Co. The decision said that the rector was undoubtedly the inventor and entitled to all the benefits of the basic patent on photographic films. The record shows that when the courts decided the film was Mr. Goodwin's patent, the widow of the inventor was awarded \$500,000.

The legal fight between Eastman and Edison, according to Mr. Cominsky's report, was threshed out in the Court of Appeals of the District of Columbia in December, 1912, when that court, in deciding an appeal from a decree on a bill by the Motion Picture Patents Company, a New Jersey corporation, against the Chicago Film Exchange, an Illinois corporation, enjoining the Film Exchange from infringement of Edison patents, reversed the decree of the lower court on the grounds that:

"The invention of Edison was exhausted in the construction of the camera which enabled the photographs of moving objects to be taken upon the Eastman film in the distinct, uniform and satisfactory manner justly claimed for them," and that "the flexible transparent or translucent tape-like film prepared for taking photographs was

neither discovered nor produced by Edison," but "was improved and brought to its present state of perfection by Eastman."

Or, in other words, as Mr. Cominsky interprets it, Mr. Edison made the machine but Mr. Eastman made the film, and the inference is that the honor of bringing the motion-picture business to its present state is to be shared by Mr. Edison with Rochester's leading manufacturer. Mr. Cominsky has nothing to say of the court action involving the rector.

The opinion of the court, as given by Chief Justice Seth Shepard, reviews the history of the contributions made by Edison and Eastman in part as follows:

"It appears that Thomas A. Edison on August 24, 1891, applied for a patent for a photographic camera and film and received the same. Claims 1, 2, 3, 4 of this were for the camera apparatus and Claims 5 and 6 covered the films used therein.

"A suit was brought by the patentee in the United States Circuit Court for the Southern District of New York against the American Mutoscope Company for the infringement of the said patent. From a decree sustaining the bill an appeal was taken to the Circuit Court of Appeals for the Second Circuit, where the decree was reversed and the bill dismissed.

"Compelled to accept this decree as final by the denial of a writ of certiorari, Edison applied for a reissue, dividing his application. The reissue patent for the apparatus having four claims was subsequently declared valid save as to one claim. He also received a reissue after some objections and amendments, with the two following claims: (Claims referring to films).

"This patent was surrendered and a reissue applied for on December 17, 1903. Reissued patent was then obtained with the Claims 1 and 2 (referring to films).

"Infringement of both claims (transparent films with and without perforated

edges) was charged in this suit (Patents Company against Film Exchange), but the decree was founded on Claim 2 (referring to films with perforated edges), which is the preferred one of the patent."

The opinion then quotes a deposition made by Mr. Edison before the lower court in which he says:

"Our experiments showed that we had to have a peculiar material * * * as we could not get any definition with paper and things like that; we had to get some glassy surface. The only surface we could get was very warty and irregular. * * * Because we were very short of light, and as we were taking photographs at a very rapid rate, we had to have something extremely sensitive, and they made us a special film different from the film that we printed on, and this special film was made extremely sensitive so that the smallest amount of light would produce great results. We, at first, did not get them very sensitive, but they, by working on them, made them extremely sensitive, so that with the small amount of light we had, they were quite satisfactory after they had experimented on them."

The rest of Mr. Edison's statement is here omitted. After completing the statement, the opinion continues thus:

"W. K. L. Dickinson, who was the principal assistant of Edison in perfecting his apparatus, said that after constructing the apparatus using the heavy

thick celluloid material of Carbutt with the toothed edge for feeding, he interviewed George Eastman, of Rochester, who was working to produce long sheets of films for his spool camera, and told him of the great importance of producing such film."

In concluding, the Court says:

"We are of the opinion that plaintiff's assignor, Thomas A. Edison, is not the inventor of the film described in Claim 2, and that his patent is therefore invalid. The flexible transparent or translucent tape-like film prepared for taking photographs was neither discovered nor produced by Edison. It was improved and brought to its present state of perfection by Eastman. When exhibited to Edison he seized upon it as the thing needed to make his camera apparatus a complete commercial success.

"We do not dissent from the proposition that Mr. Edison solved the problem of the motion picture art with great ingenuity and skill, but the problems that he solved were in the camera apparatus wherein his true claim to invention lies. * * *

So that although from the legal point of view sympathizers of each of the three persons mentioned appear to feel justified in claiming the invention of celluloid film, there still does exist a wide difference of opinion in other quarters as to just where the credit belongs. —*The New York World*.

FAMOUS "DARK DAY"

Famous dark days have occurred in history when great fear seized the people because of abnormal darkness in the middle of the day. May 19, 1780, is famous as "Black Friday," or "The Dark Day," in the history of New England. Schools were dismissed, work ceased, barnyard fowl went to roost, ordinary print could not be read at noon without artificial light, and candles were lighted. Many overconscientious people thought the Day of Judgment had surely arrived. The Connecticut Legislature, which was in session at Hartford, adjourned at 11 A. M. It is related that

in the Council, which was also in session on that day, a motion to adjourn having been made, Colonel Abraham Davenport, of Stamford, rose to his feet and said: "I am against the adjournment. Either the Day of Judgment is at hand or it is not. If it is not, there is no cause for adjournment. If it is, I wish to be found in the line of my duty. I wish candles to be brought." No satisfactory explanation for this extraordinary darkness at midday throughout New England has ever been given by scientists.—*Courtesy Tycos—Rochester*.

WINDMILLS OF CAPE COD

In the early days of the settlement of New England there were many windmills in use, particularly on the shores of Massachusetts Bay. The first of these is probably that which stood at Watertown, near Boston, previous to 1632, in which year it was moved on to Boston Neck in order to secure better wind conditions. In Somerville there still stands the stone tower of a windmill built in 1704. It did not long continue in use as a mill, for it was sold to the Province in 1747 for the storage of powder. This old mill was the powder house of the Colonial troops during the siege of Boston in 1775-76. There were many other windmills in the vicinity of Boston and along the shores of the Bay. Today they are all gone, and, with one or two exceptions, the only remaining examples are those found on Cape Cod.

Cape Cod is that long peninsula of sandy soil, which, curving out into the Atlantic like an arm, encloses Massachusetts Bay from the open ocean. The most interesting of the mills remaining there are those at South Yarmouth and Chatham, and it is these two, largely, that will be described. They are much the same in outward appearance, and a close similarity in construction renders it probable that they were built by the same man. Both bear the date 1797, and there seems no reason to doubt but that this is correct. Inside and out they are very little changed from the condition in which they left the builder's hands.

They are tower mills, octagonal in shape, and about thirty feet in height to the top of the cap. The sails are just over fifty feet from tip to tip. The cloth sail covers were tied in place on the frames when the mill was to be run, and iron eye bolts at each of the corners of the tower allow the sails to be chained fast when the mill was not in operation. The revolving cap is rotated by means of a long wooden tailbeam, to the lower end of which a wagon wheel is attached. All of these Cape Cod windmills are worn and weather-

beaten, and, occurring as they do in a region of low hills and sand dunes, they make a most attractive addition to the landscape.

These mills are built largely of oak. Eight timbers are erected upon the foundations and pinned at their upper ends to the circular wooden ring upon which the cap rotates. Horizontal cross timbers tie these together at intervals of about eight feet, and diagonal braces are framed into the resulting quadrangles. The whole frame, except for the doors and windows, is planked over, and then covered with shingles. The revolving cap rests directly upon the top of the structure, without rollers, but a liberal use was made of grease.

Most of these mills have three floors. The lowest, elevated slightly above the ground, contains the corn cracker. This machine, almost always met with in New England mills, stripped the Indian corn (maize) from the cobs upon which it grows. The corn was then carried to the second floor, where the millstones are placed. The top floor furnishes access to the gearing and the bearings.

The wind shaft found in most of the remaining mills is of pine. A wrought iron gudgeon is fastened to the rear end by iron hoops and hardwood wedges. The forward bearing is the full diameter of the shaft (about 18 inches), which is protected against wear at this point by means of iron strips let into the wood flush with the surface. Instead of being fastened with hoops, as described by Mr. Titley in his "Notes on Windmills," every strip is spiked to the shaft at each of its ends. The old millwrights called these strips "whelps." This type of main bearing is found in almost all the wooden shafted mills on Cape Cod. The shaft rests upon a cast iron pillow block in the South Yarmouth mill. The bearings could not be examined in the Chatham mill, but the miller who last ran the mill said that it was of stone.

The brake wheel in both of these windmills is eight feet in diameter, and

carries forty-eight cogs. It is built up of two or three layers of "cants" to a thickness of eight inches. Four arms attach it to the windshaft. The outside is surrounded by a brake, consisting of a number of curved wooden sections hinged together at their ends.

The vertical shaft is about eight inches diameter. An iron gudgeon in its upper end runs in a wooden bearing on a cross-piece below the windshaft. At its lower end, just about the millstones, the spindle, an iron bar $2\frac{1}{2}$ inches square, is fastened with loops and wedges. This spindle goes through the wooden "bush" in the nether stone and then to the lower floor, where it drives the corn cracker. In the Chatham mill the pinion of the vertical shaft is made of cast iron; at the South Yarmouth it is a wooden trundle gear with cast iron rungs.

While most of the Cape Cod mills appear to have been tower mills, there were some post mills. The one remaining example is near South Brewster. The post is much shortened, and the mill is partly, if not wholly, carried on iron rollers moving on a wooden track. The windshaft has a cast iron front, and is the only example of such construction found in the mills visited. This mill is certainly of a later date than any of the others. All the other mills show a great economy in the use of iron. The main bearing, the gudgeons, the spindle, the pinion gear, and the minor fittings are iron, but practically everything else is of wood. Wooden pins and trenails are used almost entirely.

The Eastham mill, which is probably well over a hundred years old, has been partly rebuilt. The cap is carried on rollers, and is much newer than the rest of the structure. Instead of having a slanting timber for turning the cap, a horizontal spar is used. This carries a counterweight suspended from it by a rope, thus helping to balance the weight of the sail arms and allowing the cap to be rotated from the ground. This mill represents the Cape Cod windmill in its most improved form; the new cap and its mechanism date from perhaps 1870.

These Cape Cod mills represent the

highest development of the windmill in New England, yet it is evident that they are crude and primitive and show little advance over the windmill as it existed in England at the time of the Puritan exodus (1620-40). In fact, these mills probably are close counterparts of the English windmill of the first half of the seventeenth century. A large portion of the immigration to New England came from the Eastern Counties. Commencing about 1620, the period of migration to Massachusetts Bay came to an abrupt end at the start of the English Civil War, and, with a very few exceptions, there was practically no addition to the population of New England until after the Revolutionary War. It seems reasonable to suppose that the windmills of these early settlers should be modeled after those they knew at home.

The Pilgrim settlers of Plymouth had been under Dutch influence during their years at Leyden, but they endeavored to retain their English life and customs. Indeed, the fear of being assimilated by the Dutch was largely the cause of their emigrating to a new country. No signs of Dutch influence ever appeared in New England. In view of this, it seems reasonable to state that the windmills from which these Cape Cod mills developed were English windmills of the period of 1620-40, and, moreover, that they probably reflected the practice of the Eastern Counties.

New England windmills never reached a stage of development much beyond that of these early mills. They contained only the bare essentials. None probably had more than a single run of stone; and none of the later improvements, such as the "lift-tenter" and "fantail" gear, were used. The reason for this lack of development is easily explained. New England is a land of most abundant water power. Almost all the early settlements had streams near at hand, and water mills were soon built. It was only in regions such as Cape Cod, where there are few water powers, that windmills continued in use beyond the early days. This restricted use of windmills meant that there was a lack of incentive toward their improvement, and that the later mills

probably were copied from their predecessors with little, if any, change. In fact, it is almost safe to state that these mills, particularly the one at South Yarmouth, are in all their essentials almost exactly the same as the English tower mills of the seventeenth century.

The Chatham mill was running as late as 1916, but corn has not been ground regularly for many years. The mill needs only a few minor repairs to put it in running order. This applies also to South Yarmouth mill. The Brockton mill was unfortunately burnt down in 1924. Most of the other windmills have either been put to other uses or allowed to fall to decay. The old millwrights built solidly and well, but time is gradually doing its work, and, with one or two exceptions, no attempts are being made to keep the windmills in repair.

The mill-work generally corresponds with that found in England in the middle of the eighteenth century, before the introduction of cast iron parts which, principally due to John Smeaton, came into use about that time. The absence of graduated weathering to the sail-bars and their equal extension on either side of the whips, and the existence of wooden shafts with wrought iron strips to form the bearing surface of the journal, point to the very early introduction of mill-work to America which was not followed by the adoption of later Dutch and English developments. The survival of such archaic examples in the United States is most interesting. Perhaps Dutch influence may be seen in the construction of the octagonal timber towers which were a feature in the millwright's practice in that country, and an examination of details of construction of these towers might be worth while.

Several mills in the neighborhood of Cataumet (Mass.), East Orleans, West Falmouth, and Hyannisport have towers octagonal and square in shape, and are generally surmounted by a high peaked cap—the whole design being rather suggestive of the tower mills still to be found in France, and also bearing a resemblance to an old mill that exists, or did exist, near Leamington. In most cases the whip lies in the center of the cross bars of the sweep, the bars being

weathered to a uniform angle; but in one or two instances the sweeps are more or less of the present-day type, with a varying twist and a leading board. The former and cruder type of sail may be a replacement effected for appearance sake by someone without millwrighting knowledge, seeing that the ages of the mills mentioned were generally assumed to be about 160 years. There is no doubt that the Dutch type of cloth sail, which survives to this day, is considerably older than this. One mill in this country had dummy sweeps fitted, weathered *in the wrong direction*.

It was a fortunate circumstance that interest is being taken in these old American windmills, and that some of them, at any rate, are being cared for. One, for instance—at West Yarmouth—appears to have been moved to its present site for preservation some thirty years ago, and to be in sufficiently good repair as to render it still capable of grinding corn.

It is difficult to say when cast iron was first used in windmills. In the early days a tree bored to receive an iron spike constituted a wind shaft. The ogee top originated in Holland, and Smeaton used it, but few examples exist outside Lincolnshire.

Concerning the mill at Brill, there is a good deal of speculation as to whether it is a windmill or not, as its site is unsuitable.

The stone tower at Newport, which was assumed by Longfellow in "The Skeleton in Armour" to be a relic of the Norsemen, was in reality the base of a windmill.

In the early days every New England town had its grist mill, where its corn was ground. Indian corn was then the common food of the people. English wheat had been cultivated during the early years of settlement, but it did not flourish, and soon ceased to be sown. The advent of the railroad changed all this, and our wheat now comes from the West already milled. Hence the grist mill has almost entirely disappeared. Here and there you may occasionally find one running a little, usually cracking corn for cattle feed, but the little mill, once indispensable, is now a thing of the past. The displacement of

the little local mills is only another result of the centralizing and specializing trend of the present day. Before many years have passed the few surviving grist mills will have tumbled into ruins, and they, too, will become but a memory. The New England of today is far different from what it was half a century ago. New races and new customs have been added, and the final result is

yet to be seen, but old-time New England is gone forever.

We are fortunate that these few remaining windmills have lasted down to our day, and that we are able, from studying them, to realize and appreciate the great skill and painstaking care of their builders, the millwrights of old.—*Edward Pierce Hamilton, Proceedings of The Newcomen Society.*

TREES DRAW LIGHTNING

Although woodsmen's lore has long contained unwritten rules to the effect that certain trees in the forest should be avoided during electrical storms, the "searchlight of science" is now being applied by the Forest Service, United States Department of Agriculture, to the question of just what trees are most frequently struck by lightning.

The value of this study, according to the Forest Service, lies not only in the fact that it will give very useful information on where it is wise not to be when thunderbolts are being let loose, but it will furnish valuable data on the forest fire hazards incident to lightning storms and the types of trees most likely to be ignited. In view of the fact that lightning is the cause of an average of about 3,450 forest fires in the United States every year, this study is considered of great importance.

Lightning probably strikes all species of trees, but it is known that it strikes certain species much more frequently than others. European studies indicate that pine, oak, and spruce are the species most subject to "lightning stroke," and beech perhaps the least. An American study, based on more than 76,000 trees in the West, showed that 72 percent of the trees hit were western yellow pine and Douglas fir.

"The question is," says Richard E. McCardle, of the Pacific Northwest For-

est Experiment Station, "Why should one species attract lightning more than any other? Consensus of opinion, both American and European, seems to be that height of trees, especially of isolated ones, and the character of the bark have much to do with it. This means that the smooth-bark trees are less likely to be struck than those with thick, furrowed bark, and that dominant trees are more liable than the shorter trees in the forest. It has been claimed that there is no evidence to show that trees growing in any particular class of topography are struck more often than those in other classes beyond the natural tendency of lightning to hit trees on the ridges.

"There are very meagre data to show what influences character of soil, its moisture content, and the like have on the attraction of lightning. Nor is there reliable information concerning the character of the trees that are struck, whether they usually have spike tops, whole green tops, or if snags are hit more frequently than green trees. This opens a fertile field for conjecture involving such questions as: What percentage of the trees are killed? Do lightning fires originate from trees struck, from snags only, or from strikes to the ground? What proportion of the trees or snags struck are ignited, and does this vary with species?—*U. S. Department of Agriculture.*

DAYLIGHT SAVING

There is an idea quite prevalent that daylight saving is losing ground. The Merchants' Association of New York is our authority for the following compilation of the places where daylight saving was observed for 1927.

The general period of observance is from 2 A.M. April 24 (last Sunday in April) to 2 A.M. September 25 (last Sunday in September).

NEW YORK

Albany
Amityville
Amsterdam
Ardley
Athens
Babylon
Baldwin
Ballston Spa
Bay Shore
Bayville
Beacon
Bedford
Bellmore
Bellport
Blue Point
Brewster
Briarcliff Manor
Bronxville
Brooklyn
Buffalo
Canajoharie
Cedarhurst
Catskill
Center Moriches
Centerport
Chappaqua
Chazy
Chestertown
Coeymans
Cohoes
Cold Spring Harbor
Cornwall
Croton-on-Hudson
Dobbs Ferry
Doyleville
East Hampton
Ellenville
Elmsford
Farmingdale
Far Rockaway
Floral Park
Flushing
Fonda
Forest Hills
Fort Edward
Freeport
Garden City
Glen Cove
Glens Falls
Gloversville
Goshen
Great Neck
Greenport
Haines Falls
Harmon
Harrison
Hartsdale
Hastings-on-Hudson
Haverstraw
Hawthorne
Hempstead
Herkimer
Hewlett
Highland
Highland Falls
Hollis
Hudson
Hudson Falls
Huntington
Ilion
Irvington
Islip
Jamaica
Jericho
Johnstown
Katonah
Kingston
Lake George
Lake Mahopac
Lancaster
Larchmont
Lawrence
Liberty
Lindenhurst
Little Falls
Lockport
Long Beach
Locust Valley
Long Island City
Lynbrook
Malverne
Mamaroneck
Manhasset
Massapequa
Mechanicville
Merrick
Middletown
Millbrook
Mineola
Mohawk
Monroe
Monticello
Montrose
Mount Kisco
Mount Vernon
Newburgh
New Rochelle
New York
Northport
Northville

Nyack
Oriskany
Ossining
Oswego
Oyster Bay
Patchogue
Pawling
Peekskill
Pelham
Pelham Manor
Philmont
Piermont
Plandome
Pleasantville
Point O' Woods
Port Chester
Port Jefferson
Port Jervis
Port Washington
Poughkeepsie
Purchase
Queens Village
Quogue
Rensselaer
Rhinebeck
Richmond Hill
Riverhead
Rochester
Rockville Centre
Rome
Roosevelt
Roslyn
Rye
Sag Harbor
Saratoga Springs
Saugerties
Sayville
Scarborough
Scarsdale
Schenectady
Schuylerville
Sea Cliff
Seaford
Smithtown
Southampton
Southold
Springfield Gardens
Spring Valley
Suffern
Syosset
Tarrytown
Tonawanda
Troy
Tuckahoe
Tuxedo
Utica
Valhalla
Valley Stream
Walden
Wantagh
Wappingers Falls
Warwick
Watervliet
Wellsville
West Hampton
Westbury
West Point
White Plains
Whitesboro
Williamsville
Woodbury
Woodhaven
Woodmere
Yonkers

NEW JERSEY

Asbury Park
Atlantic City
Atlantic Highlands
Barnegat City
Bayonne
Belleville
Belmar
Bloomfield
Bernardsville
Boonton
Bordentown
Bound Brook
Bradley Beach
Bridgeton
Burlington
Butler
Caldwell
Camden
Cape May
Carlstadt
Carteret
Chatham
Collingswood
Cranbury
Cranford
Dover
East Orange
Egg Harbor City
Elizabeth
Elmer
Englewood
Fairhaven
Flemington
Fort Lee
Freehold
Garfield
Glassboro
Glen Ridge
Gloucester
Hackensack
Hackettstown
Haddonfield
Hammonton
Harrison
Hasbrouck Heights
Hawthorne
Highlands
Hightstown
Hoboken
Irvington
Jersey City
Kearny
Keyport
Lakehurst
Lakewood
Lambertville
Lodi
Long Branch
Lyndhurst
Madison
Manasquan
Milltown

Millville
 Monmouth Beach
 Montclair
 Morristown
 Netcong
 Newark
 New Brunswick
 North Bergen
 Nutley
 Ocean City
 Ocean Grove
 Orange
 Park Ridge
 Passaic
 Paterson
 Penns Grove
 Perth Amboy
 Pitman
 Plainfield
 Pleasantville
 Point Pleasant
 Princeton
 Rahway
 Raritan
 Red Bank
 Ridgewood
 Riverton
 Roosevelt

Roselle
 Rumson
 Rutherford
 Seabright
 Sea Isle City
 Secaucus
 Somerville
 South Amboy
 South Orange
 Spring Lake Beach
 Summit
 Sussex
 Swedesboro
 Tenafly
 Toms River
 Trenton
 Tuckerton
 Union
 Vineland
 Weehawken
 Westfield
 West New York
 West Orange
 Wildwood
 Williamstown
 Woodbridge
 Woodbury
 Wrightstown

CONNECTICUT

Notwithstanding the attempt of rural legislators to prohibit the observance of Daylight Saving by the passage of law making it an offense to show other than Eastern Standard time on clocks or timepieces publicly displayed, Daylight Saving is observed by banks, offices, stores and factories in the following places:

Ansonia	New Haven
Bethel	New London
Bridgeport	New Milford
Bristol	Norwalk
Danbury	Norwich
Danielson	Rockville
Darien	South Manchester
Derby	South Norwalk
Greenwich	Southington
Hartford	Stamford
Killingley	Torrington
Manchester	Wallingford
Meriden	Waterbury
Middletown	Watertown
Milford	Willimantic
Naugatuck	Winsted
New Britain	

MASSACHUSETTS—Entire State

RHODE ISLAND—Entire State

VERMONT—Bennington

NEW HAMPSHIRE

Nashua effects observance of Daylight Saving by starting the working day one hour earlier.

PENNSYLVANIA

Chester	Erie
Coatesville	Norristown
Philadelphia and its suburbs	
Pittsburgh and its suburbs	

DELAWARE—Wilmington

WEST VIRGINIA—Wheeling

OHIO

Due to demands for Daylight Saving in cities, towns and villages outside the Eastern Time Zone, the entire State has been put on Eastern Standard Time, effective April 8, 1927, by order of the Interstate Commerce Commission.

INDIANA

Crown Point	Hammond
East Chicago	Indiana Harbor
Gary	Whiting

ILLINOIS

Chicago and its suburbs
 Evanston

MICHIGAN

Battle Creek	Ludington
Cheboygan	Muskegon
Grand Rapids	Sault Ste. Marie
Holland	

The following Michigan cities observe Eastern Standard Time throughout the year:

Adrian	Jackson
Algonac	Lansing
Ann Arbor	Monroe
Bay City	Mount Clemens
Dearborn	Pontiac
Detroit	Port Huron
Flint	Saginaw
Highland Park	Ypsilanti

WISCONSIN

Milwaukee—Banks, Board of Trade, and some other business institutions and firms observe Daylight Saving.

BEAUFORT WIND SCALE

Admiral Sir Francis Beaufort (1774-1857) of the British Navy in 1805 arranged a scale to indicate by a series of numbers from 0 to 12 the strength of the wind from calm to a hurricane. This has been quite generally accepted in navigation and is known under his name. The following table of velocities is derived therefrom by exhaustive observations.

Beaufort scale	Wind	Hourly velocity miles per hour
0	Calm	-2
1-3	Light Breeze	2-12
4-5	Moderate Wind	13-23
6-7	Strong Wind	24-37
8-9	Gale	38-55
10-11	Storm	56-75
12	Hurricane	75

THUNDERSTORMS AND STATIC

UNIVERSALITY OF INTEREST

Weather is the common subject of conversation among the peoples in every corner of the earth. In the north-eastern part of the United States and northwestern Europe where tremendous changes occur in short periods of time and in rapid succession, remarks about the weather are probably more frequent than in the lowlands of the Tropics where the weather-changes from day to day are not so striking. Yet even in such regions, the occurrence of the daily afternoon thunderstorms, the velocity of the storm winds, and the variations in humidity give occasion for some discussion. Again in the hot desert, the native is concerned with sand storms which impede his travel and often imperil his life; or, on the other hand, he bends in thankful prayer when a rare cloud precipitates a little moisture for the first time in a year, or two, or three years. The variability of his weather may not be so great as that in the areas of a humid intermediate climate, but none-the-less vital to him.

Everyone experiences days when he feels uncommonly well—"full of pep," and again days of depression, or languor, or of restlessness. A thousand and one reasons may underlie these changes in our state of health, but careful correlation between the variability in our physical and oftentimes mental condition, and the barometric pressure or atmospheric humidity will show a very close relation. High pressure makes us "up and doing" while days of low pressure virtually sap our energy. If each person observed his particular reaction to these changes in the state of the atmosphere and then watched the barometer from day to day he could often profit thereby, consciously adjusting himself to a low or high barometer, understanding just how either level affected him.

RADIO AWAKENS INTEREST

During the past three or four years and more especially during the past two

years, the acquisition of radio sets by millions of people has aroused a new interest in the weather. People who heretofore have paid but little attention to the weather, beyond simply noting that "it's a fine day today" or "it's pretty stormy today," now show considerable concern about it, because they have made the discovery that the weather apparently affects the clarity of reception. The public is especially concerned when, after looking forward for weeks to hearing a stellar performance, the anticipated program is spoiled by a pandemonium of static—all because the weather was not right.

Urban residents, unlike our farmers, have rarely considered the weather seriously. They are not ordinarily impressed by local crop failures even if prices rise because the total effect is shared by many and the inconvenience to any single person is small. The farmer, on the other hand, knows well the seriousness of the situation because his loss may send him into bankruptcy. So it seems we have waited for the invention of a device which gives us pleasure, to make us appreciate the desirability of solving the weather problem. As good roads had to await the coming of the pleasure automobile and later the convenient auto truck and bus, so the creation among the public of a scientific interest in the weather has had to await the marvels of radio.

The whole subject of radio transmission is so young we may still say that we know almost nothing about it. As with electricity, whose behavior we understand, but whose nature we can't explain, so with radio, we appreciate its basic principles but cannot explain the transmission itself. Among the many factors affecting transmission and reception, we are confident the atmosphere is one, but we need more observations than we have and we need as many students of the problem as we can possibly interest, in order to determine accurately, the part which the atmosphere plays.

WEATHER EFFECTS ON RADIO

Recent studies of the relation between the weather and radio have led to the following conclusions:

1. If a line connecting the receiving station with the broadcasting station crosses the intervening isobars at right angles, reception is at its best.

2. The steeper the isobaric gradient (that is, the closer the isobars to each other) the stronger the reception.

3. The more nearly the transmitted waves approach parallelism with the isobars, the weaker the reception. Under these conditions fading occurs.

4. Reception in a Low Pressure area tends to be somewhat weaker than in a High of corresponding intensity.

5. Reception is weaker when the transmitted waves cross from one pressure area into another than when they travel only within one area.

6. Reception is accompanied by static when transmission crosses any part of a warm humid Low or crosses an area adjacent to an intensely-developed humid Low whose surface temperatures are above freezing. If precipitation throughout the Low is in the form of rain static will be pronounced, but if snow or ice, little or no static will occur.

7. The strength of reception for any station is a factor of both its location within a pressure area and its position with respect to the broadcasting station.

8. "Bad weather" does not affect reception, excepting as it may be the index of an unfavorable pressure distribution.

9. Reception can be as good in "bad weather" as in good weather if the pressure distribution is right.

10. Temperature does not influence reception, except as it may be the index of pressure distribution and strength of convection circulation as follows:

(a) Reception is better in winter than in summer because the cyclones and anti-cyclones are more intense in the winter period.

(b) Reception is better when temperatures are low than when high, because low temperatures usually indicate intensive high pressure areas,

that is, areas with steep isobaric gradients.

(c) High temperatures favor strong convection, a condition favorable for static.

(d) In poorly defined high pressure areas reception is poor.

11. Shallow or flat pressure areas favor much static.

AN OPPORTUNITY

In order that those who are interested in pursuing the problem farther and who do not have an acquaintance with the behavior of the atmosphere as indicated upon the daily weather map, may be better equipped to carry-on an investigation, we submit a brief statement in non-technical terms relative to the present knowledge of the atmospheric circulation. The field is one of great importance and the opportunity for each one to render a service to his fellowman should attract many. Two possibilities appear in connection with these studies, namely, the determination of the exact relation between weather and radio reception and transmission on the one hand, and on the other, the discovery of the exact behavior of the circulation of the atmosphere which may lead to increased efficiency in both daily and long range weather forecasting.

THUNDERSTORMS AND STATIC

The thunderstorm as an atmospheric phenomenon, characteristic of nearly all climates in middle latitudes, is familiar to most people. We recognize it either by the lightning flash or, when no lightning is visible, by rumbles of distant thunder. The calm before the storm, the sudden outrush of air with its whirlwinds and dustclouds, the ensuing torrential downpour—all are common knowledge. But the interpretation of the mechanics of the storm are not so well known and the extent of the responsibility of thunderstorms for the occurrence of static in radio continues in the realm of uncertainty. It seems, therefore, worth while to indicate briefly those conditions most favorable for thunderstorm formation and their possible relation to the cause of static in our receiving sets.

Moisture, heat, and convection are

fundamental to the existence of thunderstorms. Given a moist surface under a hot sun and an atmosphere which is relatively dry, that is, in a state which will readily permit it to take up water vapor, evaporation of the surface moisture will proceed freely. This process establishes a convection current which attains a strength dependent upon the availability of the moisture, the dryness and calmness of the air, and the intensity of the heating. As the moisture-laden air rises, it cools by expansion. Condensation becomes effective when dewpoint is reached and then cumulus clouds form.

When the condensed water vapor is converted into drops so large that they become too heavy to float, in other words too heavy for the air to support, they begin to descend as rain. Now, if in the condensing process extra large or so-called oversize drops form, they may be broken up into droplets of varying sizes, en route toward the earth, by the strong updraft of air in the convection current. Accompanying the tearing asunder of the rain drops is the production of positive and negative ions. The finer drops, usually associated with negative ions, are carried back into the cloud layer, while the heavier positively charged drops either continue to earth or, like the minute drops are carried back to the cloud layer. The positive and negative charges respectively accumulate in different parts of a cloud creating excess charges at different points, as for example, an excess of positive charges in the cloud base and an excess of negative charges in the cloud top, thereby producing an unstable electrical condition. Discharges follow which momentarily at least return that particular part of the atmosphere to a state of equilibrium. The discharge is called lightning. Some discharges are effective between a cloud and the earth or between the invisible cloud tops:

STATIC WITHOUT THUNDERSTORMS

Are these discharges the cause of static and is the thunderstorm a prerequisite to static? The answer to this query must be negative, judging from a study of the relation between lows and poor reception in the northern part

of the United States during the months of January, February and March, 1926. In passing, we should note that thunderstorms are always associated with lows, occurring most frequently in the south-east quadrant; however, all lows are not characterized by thunderstorms. It appears that the building up of the electrical charges in the upper air, in a manner which creates a large difference in potential between the atmosphere and the earth's surface or between any two clouds or parts of clouds, constitutes the basic factor in producing static. No doubt, as rapidly as these charges are gathered, discharges occur, many of which are so small as to be inaudible at the earth and the spark in the discharge path invisible. Normally we would not construe such action as a thunderstorm because at the earth people would be unconscious of its existence. We should therefore think of a thunderstorm not as the cause of static but as an index of what is happening in the upper atmosphere.

The conditions indicated above relating to the formation of thunderstorms, included convection as one requirement. This factor can not be overemphasized, for convection may be so strong, even in the absence of high temperatures, as to strongly ionize the atmosphere. The distribution of the charges may, however, be such as not to result in discharges of the same magnitude as in a thunderstorm. In other words, a strong updraft of moisture-laden air under conditions which allow of condensation of the moisture and subsequent disruption of the rain drops will develop an electrical potential as disturbing as that induced by the thunderstorm. Consequently, in the absence of the thunderstorm and even in cold weather, if convection accompanied by a humid atmosphere is strong, that is, if the pressure reading in the center of a wet low is very low, perhaps 29.4" or less, radio reception may be as much interrupted by static as when thunderstorms are widespread. Conditions similar to these often existed in the eastern part of the country during the first three months of 1926 and were apparently largely responsible for the difficulties in reception experienced by so many listeners.

In winter, when condensation in the upper air results in the formation of snow, the mechanics are identical with those when rain forms, but fewer charges accumulate due either to weaker convection aloft, or to the oversize snow crystal occurring less frequently than the oversize water drop or being less susceptible to breakage because of its slight resistance to the air.

SUMMARY OF THE RELATIONSHIPS

From this brief discussion of the relation of the thunderstorm to static we should reach the following conclusions:

1. Thunderstorms do not cause static but are an index of conditions favorable for static.
2. Thunderstorms are not a prerequisite to static.
3. Static conditions are merely an indication of a state of unstable electrical equilibrium in the atmosphere.
4. Ionization of the atmosphere may be accomplished as readily by intense humid Lows at low temperatures as

those less well developed at high temperatures.

5. Owing to the less favorable conditions for the breaking up of snow crystals than of rain drops, static is normally much less common in winter than in summer.

To these conclusions we may append the statement that these assertions do not apply to short wave lengths such as 40 meters or less, since they seem not to be seriously disturbed by thunderstorms. Furthermore, we must not assume that the ionization of the atmosphere is due solely to the convection circulation. Other influences such as the earth's magnetism or solar radiation may have equal or greater importance.

With the characteristics of the pressure areas before us and of the thunderstorm's relation to static we may now consider the larger aspects of the fascinating field of weather forecasting.—*Eugene Van Cleaf in Tycos—Rochester.*

THE WETTEST AND DRYEST SPOTS ON EARTH

Mark Jefferson, in the *Geographical Review*, presents data as to the coldest place and also places of highest and lowest annual rainfall. The lowest temperature so far noted was -90 degrees, Fahrenheit, at Verhoyansk in Siberia in January, 1885 and 1892. Long rainfall records at a point on the plateau north-east of Calcutta at an elevation of about 4,200 feet show annual falls ranging from 427 to 449 inches, more than 10 times that of the average of the eastern United States. Observations at a nearby point on the same plateau showed a fall of almost 500 inches, but such a record is not comparable with the long

ones. At a point in the Hawaiian Islands a fall of 561.86 inches was noted in 1918. The least fall observed in long periods is in the Chilian nitrate desert, about one-fifth inch having been recorded at Iquique. High annual rainfall is not necessarily coincident with very frequent rains, as the precipitation may often be small. At a point in the Marshall Islands 336 rainy days have been noted in one year. A traveler in the Orinoco basin said that in the dry season it rained every day and in the wet season all the time.—*Courtesy of Current Topics.*

WEATHER INFORMATION

USED PRACTICALLY

Public utility companies of all kinds make use of Weather Bureau information to effect economies on a large scale. In the Middle West, for example, a number of public utility companies maintain a joint committee to work in cooperation with the Weather Bureau to investigate the weather effect on the loss in weight of coal in shipping. Again, officials of a large railroad in Montana are asked by their headquarters in St. Paul why there has been a noticeable falling off in coal shipments to that state as compared with previous winters. Weather records show that there has been a period of unusually mild weather, and thus answer the question. Along similar lines is the request made by the local lighting company of a large city for a comparative statement from the Weather Bureau at the close of any unusually cloudy, gloomy month, showing what constitutes an average

month and why the one just past has been unusual. This report is sent to consumers of electricity with their monthly bills as an explanation of any increase in the amount.

Private business also uses weather records to keep watch over small economies. An ice-cream manufacturer supplying a number of nearby towns makes use of weather forecasts in summer to vary the amount of cream to be made and sent out, as the consumption varies from day to day, depending on the temperature. In winter the coal dealer watches the weather forecasts for a cold wave so that preparation may be made for handling an increased demand for coal. If a cold wave is expected on Sunday the yards must be kept open and special forces held in readiness to handle the coal.—*U. S. Department of Agriculture.*

HIGHEST NATURAL AIR TEMPERATURE

The highest natural air temperature ever recorded with the aid of a tested thermometer exposed under approved conditions is 136.4 degrees, Fahrenheit. This temperature was recorded on September 13, 1922, at Azizia, in the semi-desert plain of Jefara, in northern Africa, between the coast of Tripolitania and the interior plateau. This temperature is 2.3 degrees higher than the previous record of 134.1 degrees re-

corded in Death Valley, Inyo County, California, on July 10, 1913. Temperature extremes, even in continental regions, tend to lag well behind the corresponding extremes in the intensity and duration of sunlight. In many of the Mediterranean countries, September is hotter than June, July or August. Moreover, some of these regions are hotter in summer than are equatorial regions.—*Courtesy Tycos—Rochester.*

"RAINING CATS AND DOGS"

The odd but familiar expression, "Raining cats and dogs," originated in the following way: Dogs used to be regarded in northern mythology as symbolic of wind. Waves on the ocean in advance of a storm used to be called

"cat's paws" by the seamen. When a heavy storm came up with wind, therefore, the sailors with characteristic mixing of metaphors used to say that it was "raining cats and dogs."—*Courtesy Tycos—Rochester.*

FREEZING WATER PIPES

WHY

Every householder knows that hot water pipes freeze quicker than cold water pipes. But why?

Seemingly there should be no reason, as in the ordinary home the hot water and cold water pipes usually parallel each other and therefore both are exposed to the same external temperatures at all times.

The fact remains, however, that in zero weather the careful householder turns off his hot water and lets the cold water drip in the bathroom to prevent freezing. Others not so careful may turn on the hot water on a zero morning and discover that the pipes have frozen while the cold water faucet produces a welcome stream. Even if the cold water pipes are frozen he knows that the hot water pipes congealed considerably in advance.

Despite the common knowledge of this occurrence the first laboratory demonstration of this seeming phenomena has been worked out by Leon McCulloch, research engineer of the Westinghouse Electric and Manufacturing Company. He is the first to give a scientific explanation of this occurrence which has heretofore seemingly violated natural laws.

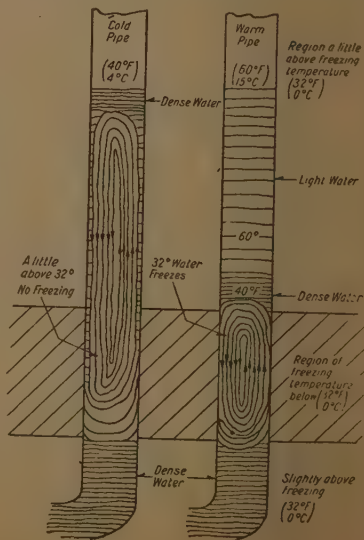
Although it was some fifteen years ago that he first heard of this peculiar behavior of pipes, he has always believed that it could not be true, and the matter being so far removed from his ordinary line of work, he had given it no thought. A few weeks ago, however, during freezing weather his own hot water pipe froze and in the process of thawing it out he sought to find a reason.

He saw what appeared to be a possible explanation, so determined to set up laboratory apparatus to find out whether or not this explanation would stand the test of experiment. After two weeks of intermittent work, a convincing theory was developed that could account for the more rapid freezing of the warm pipes.

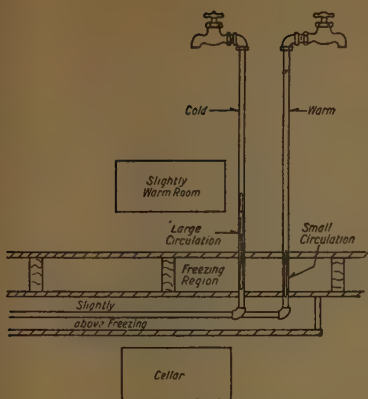
The new explanation is based upon a

well-known fact that water is densest or heaviest a few degrees above freezing. On either side of this temperature, which is 39 degrees, Fahrenheit, the water is lighter. For example, at 44 degrees, Fahrenheit, one quart of water weighs 945 grams, at 39 degrees, Fahrenheit, it weighs 946 grams, while one quart of ice weighs only 887 grams.

Thus water changes in weight only about one part in 1,000 when its temperature drops from 39 to 32 degrees, Fahrenheit, but water is such a mobile fluid that this small decrease in density is enough to set up a circulation by convection when the lighter 32-degree water is at the bottom of a vessel and the heavier 39-degree water is at the top. If we have a tube or pipe containing water at its greatest density, 39 degrees, Fahrenheit, we can set up circulation and change the temperature of all the water in the tube whether we apply heat to the bottom of the tube or whether



THE TWO FREEZING ACTIONS



THE USUAL SITUATION

water kept in circulation depends upon the height of the 39-degree point above the place of freezing temperature.

Now in a pipe which is kept cold, the point where the temperature is 30 degrees will naturally be found much higher up, farther from the point of freezing, than will the similar point in the warm pipe. The amount of water kept in circulation in the cold pipe will thus be much greater than the amount that circulates in the warm pipe. The circulation in both pipes tends to keep the water at the bottom from freezing, since the coldest water rises and the warmer water falls. Since there is more water in circulation in the cold pipe than in the warm, it is more difficult to freeze the cold pipe than it is the warm one and the cold pipe will not freeze so soon as the warm one. It may not freeze at all.

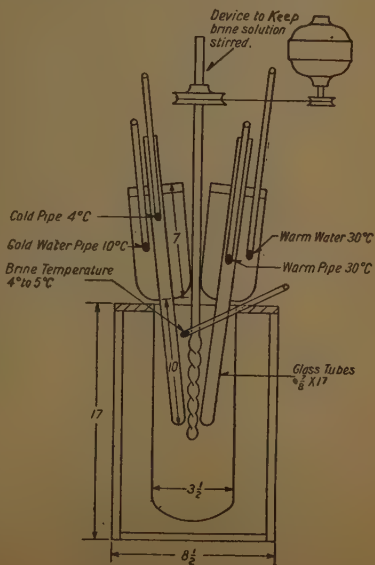
The actual water pipes in a house are not closed at the lower end, of course, but the conditions may be such that it amounts to the same thing. For there is

we cool the bottom. For whether we heat or cool, we cause the bottom layers of the liquid to become lighter and to rise, while the denser layers fall to the bottom, where they in turn become either heated or cooled, as the case may be.

Suppose a closed pipe is filled with water and the lower end is cooled very slowly to the freezing temperature. As the water cools toward 39 degrees it becomes denser and no circulation takes place until we cool below the 39-degree point. But when the water falls below this temperature it commences to become lighter than the layer of water at 39 degrees which lies above it. This denser 39-degree water therefore starts to fall and the colder but lighter water rises out of the way. Thus a circulation is set up as the point of freezing is approached. This circulation, however, does not extend all the way up the tube but takes place only below that point in the pipe where the water is densest, which is where the temperature is about 39 degrees, Fahrenheit.

Above this point in the pipe the water remains warmer and since it is lighter than the colder water below, it takes no part in the circulation.

Since the circulation extends from the point of freezing temperature to the 39-degree point in the pipe, the amount of



THE TEST APPARATUS

often a horizontal stretch or pipe, along a cold ceiling, for example, just before the pipes pass a freezing cold space through a floor into a slightly warm room above. The horizontal pipe prevents convection and thus has the same effect practically as if the pipes were plugged at the bottom of the vertical portions.

When a hot and a cold pipe pass up from a freezing region into a slightly warm room, the cold pipe may remain at about the 39-degree point, while the warm pipe, if slightly protected, may remain at a higher temperature long enough for the exposed portion to freeze solid. The cold water will be kept from freezing by the circulation.



A TAPERED ROLLER BEARING WITH BORE OF FORTY-TWO INCHES WEIGHING OVER TWO TONS

COLD HEAT

There is apparently such a paradox as cold heat—at least it is a fact that in the Research Laboratory of the General Electric Company there are men who nonchalantly thrust their bare hands into an electric furnace which melts metals with ease. Still another astonishing fact about this furnace is that white mice will stay in it, even though the current is on and even though it is a simple matter for the mice to run out if they desire to do so. Again, it is possible to heat to incandescence the interior of a radio tube without heating the glass bulb itself, simply by inserting the tube in the furnace. Another interesting experiment can be performed with an incandescent lamp, to the base of which there has been attached a single loop of wire; by bringing the lamp near the furnace, the filament can be made to glow.

It will be noted, however, that before a person thrusts his hand into the furnace he is careful to remove any rings from his fingers. Similarly, the metal drinking cup for the mice is not placed in the furnace itself but in an extension of it, although the mice spend most of their time in the furnace proper.

The secret is that the furnace heats electrical conductors only, and the reason is that the equipment is a high frequency induction furnace.

The furnace can be likened to a special transformer in which the primary is a coil of copper conductor, within which is placed the mass of conducting material which is to be heated or melted. This material serves as the transformer secondary. The current, fed into the coil at relatively high voltage, is reduced in voltage in the secondary, with a corresponding increase in amperage.

The current in the primary does not materially heat the coil, but the mass of metal serving as the secondary is rapidly heated to the melting point—and even higher if so desired—because of the rapid changes or oscillations in the current. These rapid changes also keep the melt in constant motion, so

that thorough and complete mixing of alloys is assured. The operating voltage and amperage can be used to regulate the temperature, and the furnaces are so constructed that different frequencies can be employed—some work requires relatively low temperatures or low frequencies, and other work requires much higher temperatures or frequencies. Frequencies ranging from 90,000 to 1,000,000 cycles per second have been used, with from 300,000 to 500,000 cycles as average.

Ring-type induction furnaces, of which many of large size are in commercial use, are designed on a different principle—that of an iron-core transformer in which a loop of molten metal serves as the secondary. The two types of furnaces differ in many respects. The frequency of the current is not the controlling feature in the ring-type furnace; and the ordinary commercial frequency is employed in the primary.

High frequency furnaces have been in laboratory and commercial use for years. The melting of precious metals, the heat treatment of steel tools, and the mixing of special alloys are among the industrial applications of this type of furnace; and there are many other fields in which the apparatus can, and will, be employed.

One of the most interesting and commercially important applications is in the manufacture of radio tubes. It is easy enough to say that, to obtain the necessary high vacuum within the tube, it is simply necessary to remove all instead of most of the gas by means of efficient vacuum pumps, but in actual operation the story is quite different. A tube might appear to be so completely exhausted that no trace of gas is apparent, and yet as soon as the filament is lighted there might be plenty of evidence that the tube contains gas—the presence of gas being indicated by a bluish haze within the tube. The reason is that metals and glass absorb large amounts of gas and water vapor, and added quantities stick to the surfaces. The bubbles are driven out by

the heat from the tube filament. They must be expelled from both the glass and metal parts of the tube, and it is not possible to subject the glass to anywhere near as high a temperature as the metal parts require. The high frequency furnace solves the problem.

While the tube is being exhausted it is kept at as high a temperature as the glass will withstand without softening and collapsing, but this temperature is not sufficient to boil the gas and moisture from the metal parts. Just before the radio tube is sealed from the vacuum pump it is placed for a moment within a high frequency coil. The metal parts immediately become red hot and the bubbles of gas and vapor are boiled out. The tube is then sealed from the pump, with the knowledge that later heating of the tube by the filament will not cause further release of bubbles.

In this age of machinery, it almost necessarily follows that the high frequency induction heating of the tubes is automatic. Just before the tube is

sealed from the pump, a high frequency coil on the end of a mechanical arm automatically descends over the tube, and for a few moments the tube is subjected to the influence of the field of the coil. The metal parts glow, the gas bubbles escape and are removed by the pump, the coil is automatically removed, and the tube is ready for the sealing process.

The high frequency furnace used in vacuum tube work would hardly be recognized as a furnace. It is simply a coil of copper conductor attached to a wooden handle, drawing its power from a nearby metal cage on wheels. Within the cage is the equipment for changing the ordinary 60-cycle power to oscillatory current of the desired frequency. It includes a step-up transformer, a couple of radiotrons, and a bank of high voltage mica condensers.

High frequency and high vacuum—millions of cycles and millionths of an atmosphere—are two requisites of vacuum tubes which research has conquered.

DEEPEST WELL IN THE WORLD

Temperatures which melt electric batteries have been encountered in the work of drilling a well in Orange County, California, already established as the deepest hole in the world. The depth now has passed 8,000 feet—more than 250 feet deeper than the former record made by the shaft of the People's Natural Gas Company on the Lincoln Highway near Pittsburgh. At the depth of 7,000 feet in the California well, temperatures far in excess of 212 degrees were met and the battery of the photographic machines used in making depth surveys become thoroughly molten. The melting point of this equipment is 212 degrees.

Besides being the deepest well in the world, the new shaft is the only well

ever drilled by electric power to a depth of more than 6,000 feet. The well was started on March 13, 1925, and drilling has been continuous. Engineers in charge say that drilling will continue as long as possible. A 5¾-inch bit is used, with Westinghouse transformers and variable-speed motor.

The shaft of the well has veered from the vertical, drifting 560 feet away from the center at 5,985 feet. Since that depth was reached, the drift has been back toward the center. At 8,000 feet the well is only 28 degrees off.

Other deep wells, aside from the two already mentioned, are: Rosecrans Field, California, 7,591; Fairmont, West Virginia, 7,579; Czuchow, Germany, 7,348; Dominguez, California, 7,320; McDonald, Pennsylvania, 7,248.

OIL-ELECTRIC LOCOMOTIVES

COST OF OPERATION

Railroad records on the comparative performance of steam and oil-electric locomotives, surveyed for the first time by the Ingersoll Rand Company, show to the advantage of the oil-electric type a possible saving of \$337,000,000 a year. The oil-electric operating cost for fuel, oil, water and other engine supplies was found to be only one-fourth that of steam.

The survey, made public recently, covers all oil-electric locomotives now in service on twelve Class 1 railroads. It includes locomotives of both the 60- and 100-ton type, and covers 173,465 miles of active service.

The average operating cost of the oil-electric locomotives for fuel and lubricating oil, grease, water and other engine supplies was 4.8 cents a locomotive mile. This compares with an average cost for the same items for steam locomotives engaged in yard service on all Class 1 railroads of 22.8 cents.

The average cost of operation of 60-ton oil-electric locomotives, covering 135,983 miles, was 4.4 cents a locomotive mile. For the 100-ton oil-electric the cost for fuel, oil, water and other engine supplies was 6.8 cents.

Fuel cost is the biggest single item, other than wages and repairs, in the operating cost of both steam and oil-electric locomotives, and in this item, the survey shows, the biggest saving in oil-electric over steam operation.

The average cost for fuel oil for the 60-ton oil-electric locomotive, with fuel oil figured on a cost basis of five cents a gallon, is 2.9 cents a locomotive mile. For the 100-ton oil-electric the fuel cost is 4.8 cents. This compares with an average fuel cost for all steam locomotives engaged in yard service on Class 1 railroads, on the basis of returns to the Interstate Commerce Commission for 1925, of 20.6 cents a locomotive mile.

For lubricating oil and grease the operating cost of the oil-electric locomotive is higher than for the steam

locomotive. The 60-ton oil-electric costs an average of 1.5 cents a mile for lubricating oil and grease, as compared with an average cost of one-half cent a mile for steam locomotives.

In water costs there is a very distinct saving in favor of the oil-electric. Four railroads, users of oil-electric locomotives, reported the water cost as negligible, while five other railroads reported a water cost of .000024 cents per mile. The cost for water alone, not taking into consideration the necessary accessories such as tanks, troughs and reservoirs, for steam locomotives averages about 1.3 cents a locomotive mile.

Class 1 railroads spent \$73,977,000 in 1925 for fuel, oil, water and other engine supplies for steam locomotives engaged in yard service. Oil-electric operation, on the basis of the figures now made available for the first time as a result of the survey, would make for an annual saving to the railroads, in yard service alone, of \$55,000,000. If the same ratio of saving was applied to all steam locomotives now in use, oil-electric operation would effect an annual saving of \$337,000,000 in the items of fuel, oil and water alone.

The survey also disclosed an availability record of 85 percent for the oil-electric locomotive. This compares with an average availability of 40 percent for the steam locomotive. Five railroads reported the number of days oil-electric locomotives had been in service. Over a period of 1,011 days, six oil-electric locomotives were operated an average of 20.5 hours a day. Figured on this basis, the oil-electric locomotive is capable of giving twice as many hours of locomotive service as a comparable steam locomotive, and can do the work of two steam locomotives. This is being demonstrated on one of the railroads where two oil-electric locomotives are now doing the work that formerly required the services of four steam locomotives.

RAILWAY OPERATION

COMPARISON WITH 1926

In brief, railway operations in 1926 can be summarized as follows:

1. Record breaking freight traffic, which continued throughout almost the whole of the year at a high level.

2. Passenger traffic that fell 1.5 percent below 1925. The passenger business in 1926 was less than in any year since 1916.

3. Satisfactory condition of transportation service, there being only a few and local instances of congestion or accumulation, and an almost complete absence of car shortage.

4. Condition of virtually maximum performance in many of the factors of operation, and a high level of attainment in all other factors.

5. Total operating revenues greater than in any previous year.

6. Total operating expenses greater than in any previous year except 1920 and 1923.

7. Further reduction of the operating ratio, bringing it down to 73.1 percent for 1926, and lower than in any year since 1917.

8. A total of railway taxes that for the first time surpassed \$400,000,000.

9. Net railway operating income greater than in 1925 by 8.2 percent, and greater than in the previous peak year of 1916. The rate of return on property investment for the year was 5.13 percent, which was less than in 1916. Because of rapid growth in railway capital investment during recent years, the improvement in rate of return has been much slower than in aggregate net income.

TRAFFIC

The freight traffic of the railways of the United States in 1926 was the greatest ever recorded. If the traffic be measured in terms of revenue carloadings, the increase over 1925 was four percent, and over 1923, the next greatest peak year, was seven percent. In net

ton-miles, which includes non-revenue freight, the year 1926 also broke all previous records, being seven percent greater than in 1925 and 6.8 percent greater than in 1923.

The passenger-miles were 1.5 percent less than in 1925, and by a greater margin were less than that of 1924, 1923 or 1920. In fact, the almost constant recession in passenger business since 1920 has resulted in a cumulative decline of twenty-five percent during the past six years.

The revenue carloading figures are the sum of the tabulations made each week by the Car Service Division of the American Railway Association.

Net ton-miles are reported by the railways monthly to the Interstate Commerce Commission, and include both revenue and non-revenue movement. The passenger-miles are also based upon the monthly reports of the carriers to the Commission, and include revenue movement only.

Some of the entries for 1926 in the table are partially estimated, and will be subject to revision when the final returns for the year become available. This is true of all subsequent tables, as well as charts, in which returns for the whole of the year 1926 are presented. All the statistics pertain to railways of Class I, unless otherwise noted.

Table I—Traffic Results

Revenue Carloadings	
1926	53,310,000
1925	51,224,000
5-year av. 1921-1925	46,420,000
1923	49,812,000
1920	45,118,000
Net Ton-Miles	
1926	488,578,000,000
1925	456,087,000,000
5-year av. 1921-1925	412,840,000,000
1923	457,607,000,000
1920	449,125,000,000

Passenger-Miles

1926	35,417,000,000
1925	35,964,000,000
5-year av. 1921-1925 ...	36,590,000,000
1923	38,008,000,000
1920	46,848,000,000

Perhaps the most interesting feature of Table I is the item of aggregate carloadings for 1926. This aggregate of 53,310,000 cars represented for the first time a weekly average of a million cars or more, extending over a period of one calendar year. This feature is so striking that the next section is devoted to a brief story of the gradual climb of the railway freight service to a basis of a million cars per week.

FREIGHT-CAR LOADINGS

One index of the trend of railway freight traffic is found in the weekly statistics of cars loaded with revenue freight, compiled by the Car Service Division.

These statistics are now available since the beginning of the year 1918. During the nine-year period from 1918 to 1926, inclusive, the carloadings have shown, with some recessions, a generally upward tendency.

The average weekly loadings for each year of this nine-year period have been as follows:

1918	858,000
1919	804,000
1920	868,756
1921	831,000
1923	958,000
1924	933,000
1925	985,000
1926	1,025,000

The increase from a weekly average of 858,000 in 1918 to more than a million in 1926, represents a rise of 19.5 percent in eight years, or an arithmetical average increase of two and one-half percent per year.

Not only was a new peak of weekly loadings reached in 1926, but the highest previous monthly and yearly totals were also surpassed. In fact, the previous high level for any single week, which had been reached in 1925, was exceeded in ten different weeks during the year 1926.

FREIGHT TON-MILES

In terms of ton-miles, as well as carloadings, all records for railway freight service were broken in 1926. The total of 488½ billion net ton-miles for the year was greater by 32½ billions, or seven percent, than in 1925. The previous peak had been reached in 1923, but this was surpassed in 1926 by 6.8 percent.

Ton-miles showed a greater relative increase in 1926 than did carloadings. This difference between carloadings and ton-miles, in respect to the rate of increase for 1926, held generally throughout the year. In January, carloadings actually declined under the corresponding month of 1925, whereas ton-miles showed a small increase. Every other month reported increases for both factors of freight movement, with the rate of increase in ton-miles always greater than that of carloadings. The explanation of this difference seems to lie in the larger proportion of coal movement in 1926 than in 1925, and the slightly smaller proportion of miscellaneous and merchandise freight in the total.

Table II shows briefly the peak years of ton-mile traffic from 1896 to 1926, a period of three decades of growth in railway development and service.

*Table II—Peak Years of Freight Traffic
(Revenue ton-miles, all railways)*

<i>Year</i>	<i>Revenue ton-miles (billions)</i>	<i>Percent increase over preceding peak</i>
1896	95.3	
1907	236.6	148.2
1910	255.0	7.8
1913	301.7	18.3
1918	408.8	35.5
1920	413.7	1.2
1923	416.3	0.6
1926	448.0	7.6

That each successive peak since 1896 has been higher than the next preceding one, by percentages running all the way from a fraction of one percent up to nearly 150 percent, indicates the steady and continuous growth of the United States, the progress of its industrial activity, and the extent to which the railways have kept pace in meeting the demand for transportation.

FINANCIAL RESULTS

Total operating revenues of railways of Class I amounted to \$6,449,000,000 in 1926, compared with \$6,187,000,000 in 1925. This was an increase of \$262,000,000 or 4.2 percent. These revenues in 1926 were greater than in any previous year, although both the passenger revenue and the mail revenue declined. The largest increase, both relatively and absolutely, occurred in the freight revenue, and reflected the increase of seven percent in ton-miles.

Total operating expenses in 1926 aggregated \$4,715,000,000, which was an increase of \$133,000,000, or 2.9 percent, over 1925. The increase over the expenses of 1924 was 3.4 percent. Operating expenses last year were less than in 1923 and 1920, but were greater than in any other previous year.

Railway taxes continued to break all records. For the railways of Class I, the total amount of taxes paid in 1926 amounted to \$394,000,000. Including smaller lines, the total tax bill of all classes in the United States for first time aggregated more than \$400,000,000. The increase of 8.5 percent over 1925 was the greatest relative increase of any individual year since 1923, and indicates that the rising flood of taxation continues without any sign of halting, let alone recession. During the past decade, or from 1916 to 1926, the railway tax bill has increased about 150 percent, contrasted with an increase of 23 percent in ton-miles and only 3 percent in passenger-miles. No commentary is needed on the additional charge that must be placed on each ton-mile and each passenger-mile, because of this increase in the taxation burden.

Again in 1926, and for the fifth successive year, taxes paid by the railways exceeded the amount of cash dividends paid.

The total net railway operating income for 1926 was \$1,232,000,000. This was an increase of \$93,000,000, or 8.2 percent, over the aggregate of \$1,139,000,000 for 1925. The total was greater than for any previous year, but the rate of return on investment, which is the significant measure, showed a much smaller increase.

The rate of return on property in-

vestment was 5.13 percent in 1926, compared with 4.85 percent in 1925. The average annual rate of return for the five years to 1925 was 4.06 percent. While there has been an almost steady improvement in the rate earned since 1920, as indicated by the following table, a return of 5.13 percent on investment cannot be regarded as excessive compensation to railway owners for the record breaking service supplied by their railroad lines during the past year:

	Rate of return on investment
1920	0.09%
1921	2.92%
1922	3.61%
1923	4.48%
1924	4.33%
1925	4.85%
1926	5.13%

By districts, the rate of return in 1926 averaged as follows: East, 5.68 percent; South, 5.48 percent; West, 4.45 percent.

Table III is a brief summary of revenues, expenses, taxes, net operating income, and return on property investment, for the year 1926, compared with 1925 and the five-year period 1921 to 1925.

Table III—Income Account

	1926 (millions)	1925 (millions)	5-year av. 1921-1925 (millions)
Total operating revenues	\$6,449	\$6,187	\$5,946
Total operating expenses	4,715	4,582	4,630
Taxes	394	363	326
Net operating income	1,232	1,139	900
Return on investment	5.13	4.85	4.06

OPERATING REVENUES

Total operating revenues, aggregating \$6,449,000,000 in 1926, increased 4.2 percent over 1925, and 9 percent over the preceding five-year average.

The greatest relative increase, compared with 1925, was that of freight revenue, which increased from \$4,553,000,000 in 1925 to \$4,809,000,000 in 1926, or 5.6 percent.

Passenger revenue fell off \$13,000,000 to \$1,043,000,000 in 1926, which was a

decline of 1.3 percent. This closely paralleled the decline of 1.5 percent in passenger traffic.

Mail revenue declined 1 percent. Express revenue increased 2.5 percent, while all other revenues showed an increase of 4.8 percent.

Table IV is a statement of the various items of operating revenue, in which the returns for 1926 are compared with those of 1925 and the five-year period.

Table IV—Operating Revenues

	1926 (millions)	1925 (millions)	5-year av. 1921-1925 (millions)
Freight revenue	\$4,809	\$4,553	\$4,293
Passenger revenue	1,043	1,056	1,102
Mail revenue	96	97	95
Express revenue	149	145	138
All other revenue	352	336	318
Total	\$6,449	\$6,187	\$5,946

OPERATING EXPENSES

Total operating expenses for 1926 amounted to \$4,715,000,000, which was an increase of \$133,000,000 over 1925, or 2.9 percent. The increase over the annual average of the preceding five-year period was 1.8 percent.

The increased expenditures in 1926 are fully explained by the increased traffic handled and service rendered by the railways.

Traffic expenses showed the greatest relative increase, 8.1 percent, followed by increases of 6.1 percent in maintenance of way, and 3.3 percent in general and other expenses. Transportation expenses increased 2.0 percent, and maintenance of equipment 1.8 percent.

Combining the two maintenance accounts, the increase between 1925 and 1926 was \$73,000,000, or 3.5 percent. The increase in transportation expenses was \$44,000,000, which was a relative increase of 2.0 percent. In the face of a ton-mile increase of 7 percent, and a passenger service (measured in train-miles) only slightly below that of 1925, the success of the railways in control-

ling their maintenance and transportation costs within the limits named indicates a distinct advance in economical operation. This is particularly true of the transportation expenses, which reflect improved performance as to fuel consumption, heavier train loading, smaller freight damage, and many other factors of efficiency.

Table V presents the various items of operating expenses in 1926, compared with 1925 and the five-year average.

Table V—Operating Expenses

	1926 (millions)	1925 (millions)	5-year av. 1921-1925 (millions)
Maintenance of way	\$ 874	\$ 824	\$ 790
Maintenance of equipment	1,292	1,269	1,306
Traffic	115	106	94
Transportation	2,209	2,165	2,233
General and other	225	218	207
Total	\$4,715	\$4,582	\$4,630

The declining ratio of expenses to revenues has already been mentioned. This decline has been so marked and so consistent, from 1920 to 1926, that the comparative figures are worth setting down, as follows:

	Operating ratio
1920	93.7%
1921	82.6%
1922	79.3%
1923	77.7%
1924	76.2%
1925	74.1%
1926	73.1%

It will be recalled that 1920 marked an unenviable peak in this respect, there being a steady rise in the operating ratio during the war and Federal control period, from 65.5 percent in 1916 to 93.7 percent in 1920.

RECEIPTS PER TRAFFIC UNIT

The financial statistics just presented show that the railways earned increased revenues in 1926. What the public paid for railway transportation service per unit—that is, the price of transportation—is in some respects more significant

than the aggregate receipts. In the freight service, average receipts per unit were less in 1926 than in any previous year since 1920. The same holds true of the passenger service.

Average receipts per ton-mile in 1926 were 1.081 cents, compared with 1.097 cents in 1925. This was a reduction of 0.016 cent, or 1.5 percent. The average for 1925 was itself nearly 14 percent lower than it was in 1921. The further decline in 1926 brought the average for that year to a point 15.2 percent below the highest post-war average, which occurred in 1921 as the result of the rate increases of 1920.

Average receipts per passenger-mile for 1926 were slightly lower than the average for 1925, and 4.8 percent below 1921.

Table VI—Receipts Per Ton-Mile and Passenger-Mile (1921-1926)

	Receipts per ton-mile (cents)	Receipts per passenger-mile (cents)
1921	1.275	3.086
1922	1.177	3.027
1923	1.116	3.018
1924	1.116	2.978
1925	1.097	2.938
Av.—1921-1925 ..	1.149	3.011
1926	1.081	2.937

Percent decrease:

1926 under 1921...	15.2	4.8
1926 under 1921-25	5.9	2.5
1926 under 1925...	1.5	0.1—

The averages year by year since 1921, also the five-year averages to 1925, appear in Table VI.

CAPITAL EXPENDITURES

The contribution of the capital improvements of the past few years to the increased efficiency of railway operation has been so great and so marked that attention may be devoted to statistics of capital expenditures since 1923, when the railways instituted a definite program of improvement in plant and operations.

The capital expenditures of the railways of Class I during the past four years have been as follows:

1923	\$1,059,000,000
1924	875,000,000
1925	748,000,000
1926	875,000,000

Total \$3,557,000,000

This aggregate expenditure of more than 3½ billions of new capital during the past four years, which represents an annual average close to \$900,000,000 per year, supplies one significant reason why railway efficiency reached so satisfactory a level in 1926.

The total program of capital improvement on which the railways were working during the year 1926 amounted to \$1,325,000,000.

Details of the estimated capital expenditures in 1926 are as follows:

Table VII—Capital Expenditures

Locomotives	\$ 96,000,000
Freight-train cars	210,000,000
Passenger-train cars	55,000,000
Other equipment	19,000,000
Additional track	174,000,000
Heavier rail	39,000,000
Additional ballast	18,000,000
Shops, enginehouses and mach.	40,000,000
All other improvements ..	224,000,000
Total	\$875,000,000

Installations of locomotives were on a greater scale during 1926 than during the previous year. The aggregates were 2,399 locomotives for 1926, compared with 1,733 locomotives in 1925. The greatly increased tractive power of the newer locomotives represented a significant feature of equipment purchases. The new locomotives averaged 56,512 pounds of tractive effort per locomotive. They replaced so many locomotives of smaller size and power that the aggregate of pounds of tractive effort of all locomotives in service was increased by 24,000,000 pounds, while the average per locomotive rose from 40,626 pounds to 41,783 pounds.

Similarly, although installations of freight cars during 1926 were much smaller than during 1925, the trend was distinctly toward a car of larger capacity, resulting in a substantial increase in the over-all average. The aggregate

number installed during 1926 was 96,753, compared with 125,760 in 1925. The aggregate capacity of all freight cars in service increased by 658,388 tons, while the average capacity per car went up from 44.7 tons to 45.3 tons.

As in 1925, both locomotives and freight cars were retired in considerable numbers, which was one factor leading to a net increase in the number of pounds of power or tons of capacity per unit remaining in service. Locomotives on order at the end of December numbered 329, compared with 471 at the end of 1925, while the number of freight cars on order was 18,481, compared with 40,015 at the end of 1925. This indicates that deliveries of new locomotives and cars early in 1927 will be lighter than during the corresponding period of 1926, whether or not new orders are placed in larger quantity during the first few months of the new year than in 1926.

RESERVE EQUIPMENT

The number of stored locomotives ranged from a minimum of 3,841, on November 15, to a maximum of 5,978 on June 15. These surplus locomotives, the majority of which were good for immediate service, were a potential reserve of motive power for the haulage of freight and passengers.

The story corresponds with respect to surplus freight cars, in good physical condition. The surplus for 1926 ran generally below that for 1925, and to a lesser extent below the average of the five-year period.

The margin of freight car supply over car needs, in terms of car surplus, averaged well over 200,000 cars during the year.

Corollary to statistics of freight car surplus are those of car shortage. One factor is in a sense the reverse of the other; absence of car shortage may be regarded as a negative virtue, while the presence of a car surplus is certainly a positive virtue.

Car shortage was smaller in 1926 than in any recent period of time. The stubborn way in which the reports of car shortage in 1926 stuck close to zero tells the story of absence of car shortage graphically and emphatically. These reports are made on a quarter-monthly

basis. Of forty-eight compilations so made during the year 1926, three carried a story of no shortage whatever, twenty-two additional periods reported less than 100 cars of shortage, while only three reported more than 1,000 cars, and none as many as 2,000 cars.

The average shortage reported for the year 1926 was 284 cars, compared with corresponding averages of 443 cars in 1925 and 1,047 cars in 1924. The car shortage problem, which had been approaching the vanishing point in 1924 and 1925 virtually disappeared from view in 1926.

OPERATING EFFICIENCY

The average of daily car movement was higher for every month of 1926 than during the corresponding months of 1925 and the average five-year period to 1925; also that in six of the later months of the year 1926 the average surpassed thirty miles per day, reaching a record level of 34.2 miles in October. The average for the year 1926 also surpassed thirty miles, being 30.4 miles per car day, compared with 28.5 miles for 1925. This increase of 1.9 miles, or nearly seven percent, over 1925 represented a real operating achievement in railway annals.

The average daily movement of freight locomotives is also an indication of railway operating efficiency. The number of miles per freight locomotive day in 1926 averaged 61.8 miles, compared with an average of 58.3 miles for the year 1925, and 55.1 miles for the five-year period ending 1925. The average for 1926 was slightly under the highest previous average of 62.5 miles attained in 1920. The average of 67.5 miles reached in October was the highest recorded for any single month in railway history.

As in the case of freight cars, these averages of freight locomotive miles per day are computed on a basis that includes locomotives in or awaiting shop, and stored or surplus locomotives. A revision of the averages along the same line already presented for freight cars, by omitting from the calculation the number of stored and unserviceable locomotives, brings the average number of miles per "active" locomotive per day in 1926 up to 85.1

miles per day. This compares with an average of 82.3 miles for 1925, and a five-year average of 80.1 miles.

Locomotive performance in the passenger service was also at a maximum level in 1926. During each month of the year, the average number of miles per passenger locomotive per day ran consistently greater than in any previous corresponding month. The average for 1926 was 113.8 miles, compared with 110.4 miles in 1925 and 108.5 miles in 1924. The average of 117.0 miles reported for December, 1926, was the high mark for any single month. All records were thus broken in 1926, both for a single month, for each of the individual months, and for the year as a whole.

Every month but two reported an improved fuel performance in 1926 compared with 1925, while every month without exception showed considerable gains as against the five-year averages. A reduction in average fuel consumption per unit means of course an improvement. The average for the year 1926 was 137 pounds per 1,000 G. T. M., compared with 140 in 1925. These are the lowest annual averages on record. The low figure of 121 pounds per 1,000 G. T. M. reported for July and August was the best record of any single month in history.

Less striking results were achieved in the passenger service, but there was a definite improvement during 1926. The average amount of fuel consumed per passenger train car-mile was 15.8 pounds for 1926, compared with 16.1 pounds in 1925. As in the freight service, a low record for a single month was reached in 1926, 14.3 pounds per car-mile. The average for the year was also a record.

Another element of economical railway operation is that of freight claim payments. The number of claims made on account of loss and damage to freight, and also the payments made on behalf of such claims, were both reduced during 1926. This reduction fol-

lowed a number of reductions already brought about in that field, by a continuous program of freight claim prevention, carried on by the American Railway Association and the individual railways themselves. In 1920, when the peak of such payments was reached, the payments aggregated nearly \$120,000,000. In 1925, the total was brought below \$40,000,000 for the first time since the war, and a further reduction was made in 1926 to approximately \$32,000,000.

RAILWAY PERSONNEL

The total number of railway employees of Class I in 1926 averaged 1,805,780 compared with 1,769,099 in 1925. This increase of more than 36,000 is fully explained by the increase in freight traffic during the year.

The aggregate compensation of all employees during 1926 amounted to \$2,990,000,000, which was greater than in 1925 by \$90,000,000. This was a greater relative increase in compensation than in number of employees, which is accounted for by the fact that the average compensation per employee was greater in 1926 than in 1925. The increase for 1926 was on top of an increase in average compensation that occurred in 1925. The increase was made possible in part by greater earnings per hour, which in turn were due to upward wage adjustments in certain of the various occupation classes.

The various adjustments made it possible for the average railway employee in 1926 to earn an aggregate compensation of \$1,656 for the year, compared with \$1,639 in 1925, and \$1,613 in 1924.

As the number of hours of overtime worked was less in 1925 than in 1924, and only slightly greater in 1926 than in 1925, the increase in average earnings per hour and per year was due in small degree to the overtime factor, but in much greater degree to actual increases in wage rates.—*Bureau of Railway Economics.*

HISTORY OF THE AUTOMOBILE

It is always interesting to trace the history of individuals or families, as well as of geologic formations, species of the animal or vegetable kingdoms, human thoughts, inventions and constructive productions back to the beginning, or at least as far as it is possible to go. Everything in the world, be it a mighty river, a snow-capped mountain chain, a beautiful work of art, a masterpiece of engineering or a world-conquering idea, must have had a beginning. Unfortunately, it is impossible to continue the tracing back beyond a certain point, never to the actual beginning. Even the limited tracing back is often made extremely difficult, partly by the element of time, more often by the lack of authentic records of facts or events.

This brings us to the subject of this article, a brief review of the origin and evolution of the automotive industry, which, within a period of less than forty years has developed into one of the leading industries of the world. Just think! Its known beginning dates back less than forty years, and notwithstanding its tremendous growth and its importance, just a few meager and disconnected data concerning the stage of its incipency are available to those who are interested in the history of the automotive industry.

Vehicles of some kind, drawn by man power or by animals, have been known and used in antiquity and are still used. The Chinese are credited with the invention of sail-propelled vehicles several thousand years ago and travelers assure us that even now one may see such wind-driven vehicles on the primitive roads in the interior of China.

Some time during the thirteenth century, a Jesuit missionary, Father Verbrast, constructed a vehicle propelled by escaping steam acting upon a reaction wheel of the Heron type. That was, so far as is known, the first attempt to use steam as motive force for the propulsion of any vehicle. It was a far cry from the Verbrast reaction wheel to the steam engine as invented by Watt in 1765.

Even before Watt had built his first primitive steam engine, he, and before him other inventors, had conceived the possibility of using the power of steam for the propulsion of road vehicles. Ramsay took out a patent for a road steam engine in England in 1618 and about 1759 Watt obtained a patent which covered the principle of the application of steam power to road vehicles.

Not all inventors who sought to solve the problem of automotive propulsion of vehicles, saw the solution in the use of steam. Johann Hanstach, for instance, a mechanic at Nuremberg, Germany, invented early in the sixteenth century an automotive vehicle which derived its motive power from springs.

One of the first pioneers in building steam-propelled road vehicles which actually served for practical purposes, was N. J. Cugnot, a French inventor who, in 1769, built a steam tractor which was used for hauling artillery and shortly after that a steam-propelled tricycle.

Toward the end of the eighteenth and during the first half of the nineteenth century, many inventors in Europe as well as in the United States applied their ingenuity to the perfection of the



VIROT'S STEAM CARRIAGE

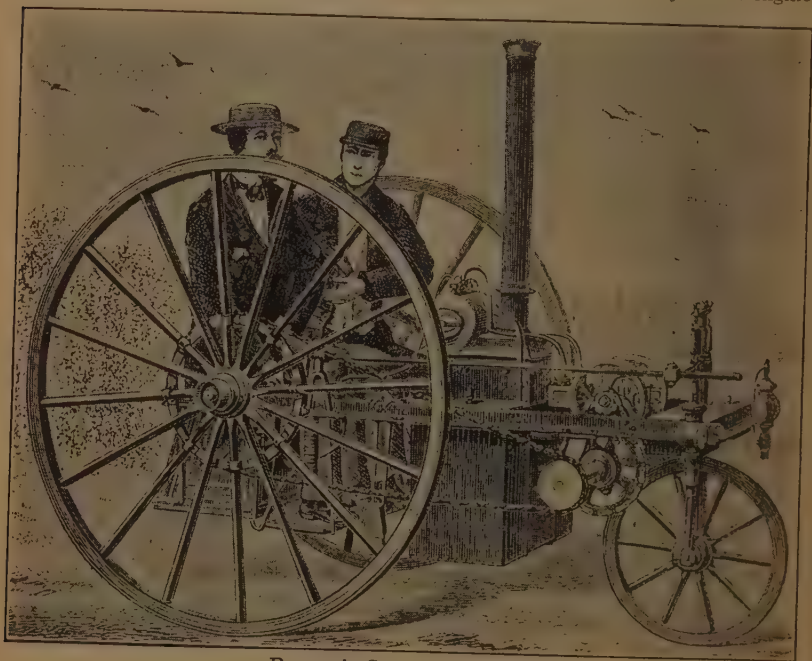
steam engine and it is not surprising that several of them devoted themselves specifically to the development of steam-propelled road vehicles.

Oliver Evans of Philadelphia, Pa., was one of the most distinguished pioneers in the development of the steam engine for locomotive purposes. He invented the high-pressure steam engine in 1799, after having invented many improvements of the low-pressure en-

Another pioneer in the development of the steam engine was Richard Trevithick, who also built a number of steam coaches in 1801-3.

The early years of the nineteenth century witnessed a remarkable progress in the development of steam engines and of vehicles propelled by such engines.

In France, in 1828, Pecqueur built a vehicle driven by a rotary steam engine



PALMER'S STEAM CARRIAGE

gine during the preceding fifteen years. He was the first to obtain privileges for the operation of steam road-vehicles, in 1787 and in 1804 built one of these vehicles equipped with one of his high-pressure engines.

William Henry James, another American inventor, who originated the tubular boiler in 1823, built a steam propelled vehicle, seating twenty persons, in 1824 and another in 1829.

with chain drive, differential gear and controlled by the Ackerman steering system, which is still in use at the present time.

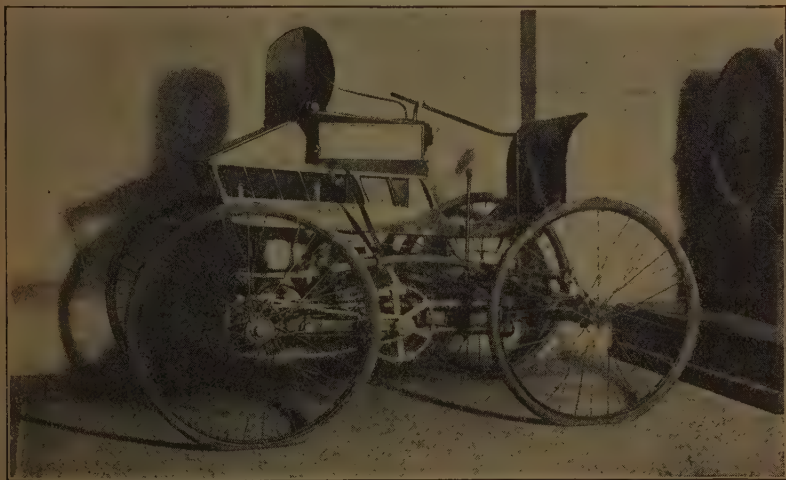
In England, Goldsworth Gurney (1825-30), Walter Hancock (1830-36), F. Hills and a number of others built many steam vehicles, mostly coaches, which ran with fair success for thousands of miles. As these heavy coaches were very hard on the roads, which

were not built for heavy traffic, Parliament placed so high a tax on these vehicles, that they were driven out of business. This naturally put a stop to all further development of steam-propelled road vehicles in England.

In the United States also, there was brisk activity in the development of steam locomotion during that period. Steam road vehicles were built in 1825 by Thomas Blanchard at Springfield, Mass.; by J. K. Fisher of New York, in 1840 and 1853; by Richard Dudgeon of New York, in 1857 and 1859, and by several others.

steam-propelled carriages and runabouts built between 1898 and 1903 and were successfully used both here and in several European countries. Another highly successful steam automobile was developed in this country by Stanley about 1901.

That steam could be used to advantage for propelling road vehicles was demonstrated by the success of the numerous types of such vehicles invented and practically used in many countries. Yet, even the best of the models were not entirely satisfactory, principally for the reason that they were



THE ORIGINAL HAYNES, 1893, IN THE SMITHSONIAN INSTITUTE

A strong impetus to the automotive industry was given in this country about 1870 by S. H. Roper of Roxbury, Mass., who developed three- and four-wheeled steam vehicles equipped with fire-flue boilers. These vehicles, which were later considerably improved by Roper's sons and other inventors, proved to be highly successful. Their steam plant was much lighter than that of other, previously built vehicles of similar type. They used gasoline for fuel, which made quicker starting possible and became the prototype for several thousand

slow in starting. The inventors, realizing this, made attempts in various directions to overcome these difficulties.

Some inventors tried electricity as motive power for road vehicles and there is now exhibited in the United States National Museum in Washington the model of an electric motor and car, invented by Moses G. Farmer as early as 1847, at a time when steam driven road vehicles had not yet reached their full development. Only a few years later, in 1851, Vail invented the electric locomotive.

After the invention of the cycle gas engine by Otto in Germany in 1877, several attempts were made to adapt engines of that type to the propulsion of road vehicles, but with little success. It was too difficult to carry a supply of gas even for a short trip, and much more difficult to generate the gas on

of that type and to apply it to the propulsion of a road vehicle was made by a Belgian inventor, Jean Joseph Etienne Lenoir. He obtained a patent on a vehicle propelled by an explosion-engine in France in 1860, but his invention was too imperfect to become a success. Lenoir was not discouraged, but



THE ORIGINAL OLDS, 1897

the way. Besides that, the Otto type of engine was inadequate for the demands made upon the engine of a road vehicle. Further experiments with gas engines were soon abandoned.

By slow degrees the idea of an explosion-engine was developed. The first primitive attempt to construct an engine

continued his efforts. Together with Beau de Rochas, a French engineer, he developed the idea of a four-cycle gasoline engine, which created considerable interest amongst engineers, when he exhibited one of these engines in Paris in 1878. It may be said that Lenoir's engine was the first successful gasoline

motor ever invented and marked the starting point in the development of gasoline engines and automobiles, as we know them today.

France is generally considered to have been the cradle of the gasoline motor and, undoubtedly was in the beginning the leader in such engines for road vehicles. It is stated by several authorities that the first gasoline tricycle which actually was used on a public road was built in 1883 by Delaure-Deboutville in France.

In Germany also, several gifted inventors did important work in develop-

ing and perfecting gasoline engines for road vehicles. Gottlieb Daimler of Stuttgart, Germany, is credited with many fundamental inventions which earned for him, at least in his own country, the honor of being proclaimed the "father of the automobile." He devised a cam system for coordinating two cylinders to work together, and introduced "hot tube" ignition to take the place of "open flame" ignition which was universally used in the earlier gas- and gasoline engines. He also built what is said to have been the first three-wheeled gasoline-propelled automobile.



SAID TO BE THE FIRST SELF-PROPELLED CAR IN CHICAGO, ACHILLE PHILON, 1893

During the years 1884, 1885 and 1886 both Daimler and another German inventor, Karl Benz of Mannheim, built a number of gasoline automobiles which, while still primitive in some respects, were practically useful.



KNOX SINGLE CYLINDER AIR-COOLED

Several years later H. Maybach, who, after the death of Daimler in 1900, became the leading engineer of the German Daimler Company, invented the spray-jet carburetor. That was in 1897 or 1898, which marked the beginning of the era of phenomenal development of the automobile industry throughout the world.

Another important step was taken by Levassor, of the firm of Panhard & Levassor, who bought the French patent rights from Daimler and invented the transmission system, which is used practically in the same form at the present time. In 1888 Levassor's firm began to turn out gasoline automobiles embodying practically all the improvements invented then and from that time on the use of gasoline motors for road vehicles became general.

In the United States, where the automobile industry developed by leaps and bounds at a phenomenal rate, the first gasoline motor vehicles were produced by C. E. Duryea in 1891 and by Elwood Haynes of Kokomo, Ind., in 1893-4.

A few statistical data will illustrate the stupendous and rapid growth of the automobile industry throughout the world.

It is generally accepted that the manu-

facture of automobiles became a specific industry in 1895. Four years later, in 1899, the total number of automobiles in the United States was about 3,700. Most of them were steam cars and runabouts, but there were also about 300 gasoline autos and about 500 electric autos, carriages, cabs and trucks.

In 1903 there were about 11,000, mostly gasoline motor cars; in 1916, approximately 1,200,000, in 1922 about 12,239,000.

The registration statistics of the Bureau of Public Roads of the U. S. Department of Agriculture for 1926 give a total for that year of 22,001,393 automobiles, representing an estimated value of \$288,282,350. Seven States, California, Illinois, Michigan, New York, Ohio, Pennsylvania and Texas, registered more than one million cars each. Seven States reported an increase of more than 15 percent in the number of automobiles over the figures for 1925. The largest increase, 40.2 percent, was reported by Florida, Oklahoma coming second with an increase of 17.8 percent.

Of the total number of automobiles registered in the United States in 1926, 19,237,171 were passenger automobiles,



AN EARLY BAKER ELECTRIC

taxis and omnibuses, and 2,764,222 were motor trucks and road tractors. The increase in motor trucks and road tractors over 1925 was 13.2 percent.

The total number of automobiles, including all types, in Europe in 1899 was

estimated at 28,000, of which France and England together had about 3,000, nearly all gasoline cars.

By the end of 1921 the total for all Europe had reached 1,255,000 automobiles of all types, of which about 500,000 were in Great Britain, 300,000 in France. The number of motorcycles in Europe at the close of 1921 was estimated at 560,300.

The world registration of automobiles for 1922 showed a total of 14,509,300 passenger cars and trucks, of which 84 percent were in the United States.

According to census figures for the year 1926, the total number of automobiles of all types in the whole world was 24,589,250, or one automobile for every 71 persons. Of these there were 19,954,347, or one to every six persons, in the United States; 815,957, or one to every 55, in Great Britain; 735,000, or one to every 53, in France; 715,962, or

one to every 13, in Canada; 323,000, or one to every 193, in Germany; 291,212, or one to every 20, in Australia; 178,050, or one to every 55, in Argentina, and 114,700, or one to every 346, in Italy. Each of the other countries of the world had less than 100,000 automobiles.

The smallest number of automobiles in proportion to the population was reported from China, showing a total of 13,680 automobiles, or one to every 31,871 inhabitants.

The world leadership in the manufacture of gasoline motor vehicles was taken by the United States in 1906 and has been maintained ever since. The wholesale value of the passenger cars, trucks and motorcycles turned out in the United States in 1925 was estimated at \$2,934,488,639, the total value of the products of the automobile industry in the United States at approximately \$3,378,900,000.—*E. Welleck.*



THIS ELECTRIC LOCOMOTIVE WEIGHS 283,350 POUNDS, HAS SIX MOTORS GIVING 4,500 HORSEPOWER. IT IS USED IN SWITZERLAND

ARMY AND NAVY RANK

There is a widespread impression to the effect that army officers rank navy officers. This is wholly erroneous. That such an impression prevails among even highly intelligent people I have satisfied myself beyond any reasonable doubt. There are many reasons why it should prevail, among which are the following:

1. In all parades on shore, when the people see the army, Marine Corps and navy march together, they see the sailors march behind the marines and the marines behind the soldiers.

2. Whenever the newspapers mention army and navy officers together, they mention the army officers first.

3. In the great majority of cases (except in Washington), when high officers of the army and navy are placed at the guest tables at public banquets and other functions, the army officers are given the precedence over the navy officers.

4. The titles of army officers are more high-sounding than those of navy officers. "Major-General," for instance, sounds much better than "Rear Admiral," though the ranks are equal, and the title of Colonel seems much finer than that of the rank corresponding in the navy—Captain.

Yet the fact is that the army and navy are exactly equal in rank, and that many years ago Congress decreed that army and navy officers of equal grades, when serving together officially, should take precedence according to the dates of their commission; for instance, that a Rear Admiral whose commission antedates that of a Major-General should take precedence of the Major-General. For that reason the present commandant of the navy yard in Brooklyn ranks every officer on the active list of the army. Yet at public functions in New York he has always been placed after the Major-General stationed at Governors Island.

Congress also decreed that the various grades of the army and navy should rank together as follows:

General	Admiral
Lieutenant-General	Vice Admiral
Major-General	Rear Admiral

Brigadier General	Commodore
Colonel	Captain
Lieutenant-Colonel	Commander
Major	Lieutenant-Commander
Captain	Lieutenant
First Lieutenant.....	Lieutenant of the Junior Grade
Second Lieutenant	Ensign

In certain foreign navies the grades of Field Marshal and Admiral of the Fleet are also held; but in the United States these grades have never existed, and the title of General has been held only by Washington, Grant, Sherman, Sheridan and Pershing, while the permanent title of Admiral has been held only by Farragut, Porter and Dewey. About twelve years ago, however, Congress accorded the temporary ranks of Admiral and Vice Admiral to Rear Admirals commanding certain fleets and squadrons, in order to place our fleets on an equal plane with foreign fleets; for the reason that, when the fleets of two powers find themselves peacefully together, they take rank, for the purpose of cooperation, according to the ranks held by their chiefs. About ten years ago, also, Congress accorded the temporary rank of Admiral to the Rear Admiral occupying the post of Chief of Naval Operations, in order to avoid the incongruity of having him in a grade below that occupied by the commander-in-chief of the fleet and other officers, who were actually his subordinates. Congress specified, however, that after giving up these positions the officers should revert to their permanent rank, Rear Admiral. As no such restriction is prescribed in foreign navies, the result is that, so far as high permanent rank is concerned, American navy officers, as well as American army officers, rank below the officers of every important foreign power.

Throughout the British Empire and in several other countries the navy is recognized officially as the senior service and is always mentioned first; though, as with us, the individual officers of the two services take precedence according to the dates of their com-

missions. In the United States the army is the senior, in the sense that it is a few months the older, but not in the sense that it is the more important. For with us, as with all other nations that

border on the sea, the navy is "the first line of defense," the protector of our commerce, the guardian of our shores.—*Bradley A. Fiske, Rear Admiral, U. S. N. (Retired), in New York "Times."*

ORIGIN OF "UNCLE SAM"

It is interesting to note the origin of the term "Uncle Sam," as applied to the United States Government.

During the War of 1812 between this country and Great Britain, it appears that Elbert Anderson of New York purchased in Troy, N. Y., a considerable amount of pork for the United States Army.

It was inspected by Samuel Wilson, who was popularly known as "Uncle Sam." The barrels of pork were marked "E. A., U. S.," the lettering being done by a facetious employee of Mr. Wilson.

When asked by fellow-workmen the meaning of the mark (for the letters "U. S." as representing United States

were then almost entirely new to them), he said "he did not know unless it meant Elbert Anderson and Uncle Sam"—alluding to Uncle Sam Wilson.

The joke took among the workmen and became current, and "Uncle Sam" Wilson himself being present, was occasionally rallied on the increasing extent of his possessions. Soon the incident appeared in print and the joke gained favor rapidly till it penetrated and was recognized in every part of the country. Cartoonists seized upon the conventional figure of a yankee and dressed him up in the Stars and Stripes, establishing thereby by representation a figure emblematic of the United States. "Uncle Sam" will undoubtedly remain our national figure while time lasts.

CHILDREN KNOW MUSIC

When out of 900 children more than 500 make a perfect score in a music memory test it is time for their elders to sit up and take notice. This happened at Orchestra Hall last spring in the culminating test of the public schools concert course provided by the Detroit Symphony Society.

The course itself begins and continues in the schools; the orchestra concerts are a contributing gift to the children of Detroit at the expense of those who support the Symphony Orchestra; by complete understanding and cooperation the school course and the orchestra grow together and those who attend any one of these concerts for the children know that for lively interest, eager attentiveness, and enthusiastic appreciation no other audience can compare with them.

Inasmuch as the Symphony Society undertook the task of providing these concerts, with a definite object in view,

it is interesting to note how rapidly they are accomplishing that object. The purpose, of course, was to educate a music-loving audience in this city, to create among the children such a taste for first-class music that good orchestras, good operas, good chamber organizations shall become inevitably a rich part of Detroit's life in the next and succeeding generations. It was a sensible plan, and it works.

It is one series of concerts that never sees an empty seat and that has an audience fully informed on the program and prepared, at the proper time, to give proof of it. The music memory test is the immediate proof; the greater proof will come with the maturity of all these young music-lovers. The city is the richer for the experiment, and the Detroit Symphony Society deserves credit for its shrewdness and generosity.—*The Detroit News.*

COAST AND GEODETIC SURVEY

The Coast and Geodetic Survey has, in the last ten years increased its activities 249 percent.

Its Director, E. Lester Jones, attributes this increase to augmented knowledge of the people regarding the Survey's contributions to the upbuilding of the country and to the reflex of the large growth of the merchant marine and the shipping industry and rapid development of cities and other centers of population, with corresponding increased commerce.

Our activities affect many angles of the business of America. We furnish latitude and longitude and exact points of measurement and direction and so on, on which everything industrially and scientifically must be predicated. There must be first knowledge of geometrical position, and on this exact position all activities must rely.

How important this is may be illustrated in a single instance in New York City. Suppose it is necessary to connect up land there with a proposed forty-story building. The first thing necessary is to look for a Coast and Geodetic Survey bench mark. They will ask us the exact position of the bench mark and on that they will predicate all the details of their work.

There is the determination of altitude in its relation to mean sea level. Suppose engineers propose constructing a project like that of the Hetch Hetchy or Roosevelt dam. They first look for our bench marks and ascertain the level at that point so as to know in planning the dam how much area the water to be dammed will cover and what the flowage will be. Again we furnish in that instance what we might call the "steel structure," theoretically, of a project—its fundamental basis.

SOLVES CITY PROBLEMS

Take Atlanta, Ga. It has grown very rapidly. The city authorities were having trouble with the pipes and they asked the Survey what size pipes were necessary to carry off the rainfall that was to be expected, as well as the sewage, without flooding the city. They

have to look ahead for a quarter of a century. We gave the city the proper controls and the situation was clarified.

Our field sheets are intact for almost 125 years back. We have the natural shore lines of continental United States. In New York City there was a lawsuit some years ago, involving \$40,000,000 worth of property along the East River. There had been many artificial changes in the shore line of Manhattan Island. We produced the original field sheets, showing the original shore line on that part of Manhattan Island along the East River as made eighty years ago and the lawsuit was settled by six dollars' worth of blueprints.

We have many cases of State boundaries where there are differences due to earlier surveys based on local controls. Sooner or later we are called upon to correct the errors, which mean nothing more nor less than the overlapping of ownership. These records and field sheets of ours are always available to people who need our assistance. They date back to 1807, when the Survey was founded.

Everything we have done in this country along these lines has been the result of the primary triangulation and primary levels which are growing of more and more importance to millions of people in this country. It was Ferdinand Hassler, born a Swiss, who came to this country in 1806 and became an American citizen, whose fundamental plan stands intact as the best system of the kind in the world.

COAST LINES CHARTED

Hydrography is our principal activity. We are charged with creating all the nautical charts of continental waters and coastal waters in our territories and possessions. Like our work on land it is all pioneer work as we discover and chart. All the waters mentioned must be charted for the safety of our Navy, the Coast Guard and American maritime interests.

On the sea, the pioneer work is the beginning of development not only in

the harbors but up the streams from these harbors, which must be safeguarded by accurate charts to protect human life and the property carried on the ships that ply these waters. In the work on land and sea, the railroad, the growth of cities, the development of sewage systems, water power, military and naval activities, the work of the Survey is important.

We are today issuing current tables to show how we are further assisting vessels at sea, which are giving to mariners knowledge of causes of former disasters and of local and seasonable currents which have been responsible for many disasters on record. Take the loss, for instance, of the naval destroyers on the Pacific Coast several years ago, the loss of the cruiser *Milwaukee* on the Pacific, and of the *Bear* at Cape Mendocino a few years ago—all results of lack of knowledge of the practically unknown directions and velocity of currents.

Our charts have increased in number from 75,000 a dozen years ago to more than 300,000 now and all our nautical work has increased accordingly. These are for the use of the maritime world.

Governments throughout the world are continually pointing to the standards of the Coast and Geodetic Survey. Foreign government officials frequently visit the Survey to obtain information about its work. Our latest visitor was Rear Admiral T. Kawamura, of the Japanese Navy. He told me he had heard of our advancement in methods of management, in charts, and in other field work.

Dr. William Bowie, Chief of the Division of Geodesy, in a statement on April 26, told of the Survey's work directed toward ascertainment of the stability or instability of the earth's surface, and of varied problems in what that service has been, and is being, engaged. One pending research is that of the determination of the slopes of mean sea level along the general coast lines of the United States. The Survey, he said, has been working vigorously in this line of scientific development, with a prospect, he said, that the results of the study would be soon available to the public.

Geodesy, as this science is called, covers both the technical and the practical field. In its theory, it deals with the shape and size of the earth, the causes for the deflections of the vertical, and the shape of the geoid, or that surface formed by the oceans and the water in sea-level canals projected, by imagination, through the continental areas. It also deals with the densities in the outer portions of the earth.

PROVES EARTH HAS SHELL

During the past twenty-five years it has been proved that the earth has an outer shell, which we may call the crust, which is rigid to long continued stresses. Below the crust there is material which is plastic in its nature, when subjected to stresses that act for hundreds or thousands of years. The outer shell or crust is practically floating on this plastic subcrustal material. The result of this condition is that the weight which is exerted on the subcrustal material per unit of horizontal surface is uniform around the whole world. This condition of uniform pressure has been termed *Isostasy*.

In its scientific studies the Division of Geodesy is charged with the duty of making investigations in regions of seismic activity to show whether the earth's surface is stable or whether it shifts horizontally or changes its elevation. About six hundred miles of arc of triangulation, which were established thirty years or more ago in Nevada and California, have been repeated in order to show how much some of the triangulation stations have shifted horizontally during the interval represented. It is well known that, during the earthquake in California in 1906, there were some horizontal movements as great as ten feet. The triangulation referred to above has shown that points that are quite a number of miles from the earthquake fault of 1906 have changed positions several feet during the past thirty or more years.

STABILITY IS TESTED

Eight hundred miles of leveling have been run in southern California to test the stability of the surface in a vertical direction. Most of this work is new,

while a small part is a reproduction of old lines of levels. A comparison of the new and the old elevations gives a measure of the vertical movement. As a matter of fact, no decided vertical movements have been indicated by the leveling but this is largely because the interval elapsed between levels has been rather small.

With triangulation and leveling extending well over any seismic region, a reproduction of the work after an earthquake will give the movements of the various stations and will also show whether the effect of the earthquake is confined to a strip close to the fault or whether areas far from the fault are affected.

STUDIES SEA LEVEL

The problem involved in the slopes of mean sea level along the general coast of the country has also been one of the studies. This is a matter that has been worked on quite vigorously during the past few months. The results of an intensive study of the relation of mean sea level at various places along the coast to a single level surface will soon be available for publication.

In its practice of what might be called engineering work, the Division of Geodesy is charged with the extension of triangulation and levels over the entire area of the United States and of Alaska. The triangulation furnishes the latitudes and longitudes of thousands of points already established for the use of the engineer engaged in construction work or in surveying, mapping or other engineering operations. In the triangulation, the distances between the contiguous stations are determined as well as the azimuths or directions of lines joining the various stations. These data are all needed by the engineer in many of his operations.

WORK IS HALF DONE

An arc of triangulation has been extended along the entire coast of the United States, from Passamaquoddy Bay, Me., to the mouth of the Rio Grande, and from the vicinity of San Diego, near the Mexican border, northward to Puget Sound, Wash. Through the country, the bureau has extended

eighteen thousand miles of arcs of triangulation which have been supplemented by approximately two thousand miles of triangulation by the U. S. Lake Survey. The triangulation of the country, as far as what might be called first order work is concerned, is approximately half done.

An arc of first order triangulation has been extended from Dixon Entrance, Alaska, northward to Skagway. This, together with an arc of first order triangulation executed along the western coast of British Columbia by the Geodetic Survey of Canada, will make it possible to extend what are called the standardized geographic positions through southeastern Alaska and, eventually, will make it possible to have standard geographic positions over the whole of Alaska and along all of the coast of that territory.

PROGRESS IS REPORTED

Much triangulation has been done through the various waterways of southeastern Alaska and an arc has been extended from the vicinity of Juneau, westward to the Alaska Peninsula, with the exception of a small break just to the southward of Mt. St. Elias. The reason for that break is the presence of a very broad glacier which extends down to the sea and prevents accurate observations being made across it. Eventually it is expected that this gap will be bridged by observations made from high peaks on each side of the glacier.

An arc of first order triangulation was extended from the head of Cook Inlet northward to the vicinity of Fairbanks. Preliminary surveys have been made for the extension of this arc eastward to the 141st meridian, which is the boundary between Canada and Alaska.

A number of States in the Union have used the triangulation data of the United States Coast and Geodetic Survey for locating the positions of their boundary monuments along their borders. Counties have also used the data of this Survey for locating their boundaries.

SOME CITIES ASSISTED

Also some cities have been assisted in the extension of triangulation over their areas. Notable examples are New

York City, Rochester, N. Y., and Atlanta, Ga. In general, the Bureau assists the cities only to the extent of having its engineers guide the city officials in planning and executing the work. Wherever work is done in the cities by the engineers of the Coast and Geodetic Survey the field expenses are paid by the funds appropriated by the cities.

The Survey has extended 34,000 miles of first-order levels through the United States, joining a number of tidal stations on the coast where mean sea level had been determined by observations of the ocean waters. This leveling has been supplemented by 15,000 miles of leveling run by the Mississippi and Missouri River Commissions, the Survey of the Great Lakes, the U. S. Geological survey and several railroads. Practically no first-order leveling has been done by any organization other than the Coast and Geodetic Survey during the past 15 years.

LEVELS ARE DETERMINED

The leveling has been done in every State of the Union except Delaware and Iowa. It is expected that this system of levels will be extended to the point where there will not be any place in the United States more than about 50 miles from a first-order bench mark whose elevation has been determined. The intermediate areas, between lines of first-order levels, will eventually be controlled for elevations by leveling of second order.

The first-order leveling is done with such a high degree of accuracy that the average closure of a circuit 1,000 kilometers in length (660 miles) is only about four inches. Some of the circuit closures have been as small as an inch in 1,000 miles.

The triangulation stations and the bench marks for the leveling consist of blocks of concrete into which have been set tablets with inscriptions telling just what they represent. These marks are made so substantial that it is reasonably certain that they will remain for many years to come. Of course, they can be destroyed by the caving in of a bank or the grading of a lot or other natural operations or the operations of man.

In the early days the Survey did not

use inscribed tablets for its surveying monuments. The result was that many of them were lost, because those finding them thought that they indicated the place where treasure had been buried. This is especially true along the coast where there were many traditions that Captain Kidd or some other pirate had buried treasure boxes. Since the use of the inscribed tablets, the officials of the Survey are notified by local engineers and others that a mark has been destroyed or, in case some engineering or other work is to be undertaken and the mark is likely to be destroyed, the Survey's Office is asked to send someone to set the mark off to the side or to authorize a local engineer to do so. This is proof that it is better to have the Survey's mark indicate exactly what it is rather than to try to have the mark very obscure in character, hoping that no one will ever be able to discover it except those who may have reports of the Coast and Geodetic Survey giving the data in regard to the various stations.

LEVELS ARE COMPUTED

As soon as an arc of triangulation has been completed or a line of levels run the various observations are computed and adjusted at the office in Washington and pamphlets or reports are issued containing the essential data. These reports give a detailed description of each of the stations or bench marks in order that others may find them without difficulty.

In carrying on the various classes of geodetic work the Survey has kept in touch with the best thought in other countries. Since 1889 it has been a member of the International Geodetic Association and later of the Section of Geodesy of the International Geodetic and Geophysical Union. By means of these contacts with international organizations the Survey's officials have been able to keep right up to date in its geodetic work. As a matter of fact, the high plane of geodesy in the world today is to a considerable extent due to the improvement in instruments and methods and the results of researches carried on by its members. The present chief of the Division of Geodesy has been, for the last eight years, President

of the Section of Geodesy of the International Geodetic and Geophysical Union.

MAKES GRAVITY SURVEYS

The Coast and Geodetic Survey is also charged with the conduct of gravity surveys over the United States. The results of the observations are of value in determining the shape of the earth. They also assist in the study of the densities and other physical properties

of the material of the outer portion of the crust. There is some possibility that the values of gravity will be of assistance in disclosing at least some of the major features of buried geological structure. This matter is of considerable importance, for if the buried structure can be disclosed by gravity observations, a means will be obtained for solving some of the geological problems that today are puzzling.—*Courtesy of U. S. Daily.*

EARLIEST TREATISE ON METEOROLOGY

Popular weather lore dates back to prehistoric times, but meteorology first achieved rank as a branch of formal knowledge when Aristotle, who flourished in the fourth century B. C., devoted to it one of the series of works in which he endeavored to round up all the scientific and philosophical learning of his age. His "Meteorologica" was well known in antiquity. Three Greek commentaries on it are still extant; viz., those of Alexander Aphrodisiensis (second century A. D.), Olympiodorus (sixth century A. D.) and Joannes Philoponus (seventh century A. D.). With the fall of the Roman Empire, however, all of Aristotle's works, with the exception of his treatise on logic, were lost to the scholars of western Europe, but fortunately were preserved by the Arabs.

At the close of the twelfth century Latin versions of these works, translated from Arabic, appeared in Spain. From that time on until the rise of the modern sciences Aristotle was the supreme and unquestioned authority on all the subjects with which his works deal. His writings became the textbooks of the universities. The fact that they

included a treatise on meteorology gave to that subject a prominence in the educational system of the middle ages that it would probably not otherwise have had. As Dr. Hellmann has pointed out, "It was Aristotle that was studied, not meteorology."

Early printed editions of the "Meteorologica" in both Greek and Latin were numerous, besides which there appeared a great number of commentaries and paraphrases. The first translation of the text into a modern language was an Italian version, published in 1555. Of other translations there is a recent one in English, by E. W. Webster, published in 1923. The latest edition of the Greek text, edited by F. H. Fobes, was published by the Harvard University Press in 1918.

The "Meteorologica" is in four books, of which the fourth deals mainly with matters that come nowadays under the head of physics rather than meteorology. The other three are broader in scope than modern works on this science, as they discuss such varied natural phenomena as comets, shooting stars, rivers, springs and earthquakes.—*Tycos, Rochester.*

OLD PAPER MONEY

Having succeeded in producing in its experimental paper mill an improved quality of paper for making the Government paper money, the Bureau of Standards has reversed the process and produced a good quality of paper from the paper money after it has served its useful life. This is a part of further effort in cooperation with the Bureau of Engraving and Printing and the Bureau of Efficiency to effect economy in Government currency expenditures.

The worn-out paper currency returned to the Treasury Department for redemption, together with a small proportion of spoiled paper and trimmings from the currency printing processes, amounts to approximately four tons daily. At the present time this material is macerated at the Bureau of Engraving and Printing and is sold in the form of pulp containing some 70 percent of water and practically all the ink. No attempt is made to clean the pulp, the process being carried only far enough to comply with the requirements for protection against unlawful use of the waste paper, that is, that it be entirely defibered so that no printed characters can be distinguished, and that all distinctive features of the paper itself be removed. In this form, the pulp is suitable for coarse paper products only, such as certain grades of boards owing to its large content of impurities which occur in the form of lumps. For this reason the price received is so low that according to a survey of the situation made by the Bureau of Efficiency, the maceration of the material is costing annually from \$15,000 to \$18,000. As the original paper is composed of the highest grade linen and cotton rag fibers, a clean pulp

produced from the waste paper should have a ready market for fine writing and printing papers at a considerably increased price. It is estimated that by so improving the product the present loss can be turned to a profit, amounting possibly to \$50,000.

The material presents unusual resistance to the ordinary de-inking treatments, owing to the hardness and toughness of the paper, the large amount of ink present, and the resistant quality of the ink. It was found possible, however, to completely de-ink and otherwise quite thoroughly clean it with semi-commercial machinery consisting of a duster, a rotary digester, and a beater equipped with a drum washer. The paper produced from the pulp compared quite favorably with good grades of fine writing and printing papers. As is to be expected, considering the wear to which the paper money is subjected and the weakening effect of the various de-inking and de-fibering processes, a large proportion of the original strength of the fibers is lost. The recovered fiber paper, however, is sufficiently strong for the purpose mentioned, being somewhat stronger than that made from new sulphite fiber and as strong as some grades of rag fiber papers made from the lower grades of rags.

The results obtained are considered so promising that it is planned to purchase the additional commercial equipment for use in the recovery plant of the Bureau of Engraving and Printing required to produce a clean pulp and to more thoroughly de-water it so as to lower the transportation cost of the product.—*U. S. Department of Commerce.*

WAR DEBTS

HOW THE NATIONS WILL PAY

Perhaps the relation of the United States to the debtor nations was never more happily put than in President Coolidge's Memorial Day speech at Arlington. The President referred to the loans made to foreign governments and foreign enterprises for the purpose of re-establishing their public credit and their private industry. He said, "By such action, we have not only discharged an obligation to humanity, but have likewise profited in our trade relations and established a community of interests which cannot be but an added security for the maintenance of peace. Insofar as we can confirm other people in the possession of profitable industry, without injuring ourselves, we shall have removed from them that economic pressure productive of those dissensions, discords and hostilities which are a fruitful source of war.

"It has been in accordance with these principles that we have made generous settlements of our foreign debts. The little sentiment of 'live and let live' expresses a great truth. It has been thought wise to extend the payment of our debts over a long period of years, with a very low rate of interest in order to relieve foreign peoples of the burden of economic pressure beyond their capacity to bear. An adjustment has now been made for all these major obligations, and they have all but one been mutually ratified. The moral principle of the payment of international debts has been preserved.

"Every dollar that we have advanced to these countries they have promised to repay with some interest. Our National Treasury is not in the banking business. We did not make these loans as a banking enterprise. We made them to a very large extent as an incident to the prosecution of the war. We have not sought to adjust them on a purely banking basis. We have taken into consideration all the circumstances and the elements that attended the original transaction and all the results that probably will flow from their settlement. They have been liquidated on this broad and

moral humanitarian basis. We believe that the adjustments which have been made will be mutually beneficial to the trade relations of the countries involved, and that out of these economic benefits, there will be derived additional guaranties to the stability and peace of the world.

"While we are thus desirous of the economic welfare of other countries in part because of its relation to world peace, we ought to remember that our own government owes a great duty to the American people in this direction. It is for this reason in part that I have insisted upon a policy of constructive economy in the national administration. If we can make the circumstances of the people easy, if we can relieve them of the burden of heavy taxation, we shall have contributed to that contentment and peace of mind which will go far to render them immune from any envious inclination toward other countries. If the people prosper in their business, they will be the less likely to resort to the irritating methods of competition in foreign trade out of which arise mutual misunderstandings and animosities."

Now, let us see what the nations have borrowed, with the amounts to be paid including interest. The terms of payment allow the debts to run over a period of sixty-two years and the total amount to be received by the Treasury, on account of principal and interest, is as follows:

Belgium	\$727,830,500.00
Czecho-Slovakia	321,811,433.88
Estonia	33,331,140.00
Finland	21,695,055.00
France	6,847,674,104.17
Great Britain.....	11,105,965,000.00
Hungary	4,693,240.00
Italy	2,407,677,500.00
Latvia	13,958,635.00
Lithuania	14,531,940.00
Poland	435,687,550.00
Rumania	122,506,260.05
Yugo-Slavia	95,177,635.00

\$22,143,539,993.10

This is a tidy little sum even though we may have to wait a lifetime for all of it. Now, let us see what the principal countries will pay the first year and the "peak" years.

Great Britain: Principal of debt (as funded) \$4,600,000,000; interest \$6,505,965,000; total \$11,105,965,000. Initial year \$161,000,000; peak year \$187,250,000.

France: Principal of debt (as funded) \$4,025,000,000; interest \$2,822,675,104.17; total \$6,847,674,104.17. Initial year \$30,000,000; peak year \$125,000,000.

Italy: Principal of debt (as funded)

\$2,042,000,000; interest \$365,677,500; total \$2,407,677,500. Initial year \$5,000,000; peak year \$80,988,000.

Belgium: Principal of debt \$417,780,000; interest \$310,050,500; total \$727,830,500. Initial year \$3,840,000; peak year (1984) \$12,868,000.

It would be tiresome to consider the other countries as the arrangements are practically the same.

So, if, as the President said, we are not in the banking business we have been at least considerate, and we almost said have "tempered the wind to the shorn lamb."

TRAINS DISPATCHED BY TELEPHONE

The telephone is used almost universally throughout the United States in the dispatching of trains, having taken the place of the telegraph which was used in the early days of railroading.

The first successful installation of telephone equipment for train dispatching was completed in October, 1907, on the lines of the New York Central. Soon after that the Chicago, Burlington and Quincy adopted the telephone, and other roads followed. In 1914 it was in use on some 85,000 miles of track

operated by more than 140 roads.

The adoption of the telephone has come about because of its efficiency, which is necessary in the dispatching of trains over congested lines where intervals between trains are short. The telephone dispatching operates somewhat as a party line, the dispatcher being able to get in instant touch with any signal tower in his territory or in touch with every tower and station on the line for a general listen-in.—*Illinois Public Utility News Bulletin.*

HEAVIEST RAINS IN SHORTEST PERIODS

Some of the heaviest rains which fall in short intervals of time in America occur in southwestern Texas, notwithstanding the general aridity of that region. This happens when certain contrasts of atmospheric pressure exist which produce conflicting currents and under-running of masses of warm air by cold air, and the elevation of warm air to such heights as to cause rapid condensation and heavy precipitation. Any process whereby large masses of relatively warm and moist air are ele-

vated and cooled thereby to the point of condensation will produce heavy rainfall, and that is what occasionally occurs in Texas. At Taylor, Williamson County, Texas, within a period of twenty-four hours on September 9-10, 1921, precipitation amounted to 23.11 inches, as officially recorded by the U. S. Weather Bureau. This is the greatest twenty-four hour rainfall ever recorded with a standard rain gauge anywhere in continental United States.—*Tycos, Rochester.*

STELLITE

A WELDING METAL

Although stellite has been manufactured for a number of years and it is now quite an important product, little has been published about it. This metal serves chiefly in the manufacture and reinforcement of machine tool bits, milling cutters, gauges, and various other products used in large machine shops.

Stellite is not a steel. It is an alloy composed of cobalt, chromium and tungsten; iron being present only as an impurity. Because electric furnaces have a high and uniform heat which gives a uniform product of practically no adulteration, they are used exclusively in the manufacture of stellite.

The component metals are charged into the furnace in the right proportions and melted down and alloyed. Frequent tests during the melting process insure high standards for the resultant product. All stellite is then cast into special composition moulds.

After it has been cast in a form, stellite can be reduced only by grinding. Because of its inherent hardness, it cannot be machined or filed.

Stellite is truly a unique metal. Its hardness is inherent, so it requires no tempering; and it can be brought repeatedly to very near its melting point without losing this hardness. Subsequent cooling does not affect it.

One of its highly desirable characteristics is the fact that it will resist wear and abrasion to a high degree. It is possible, of course, to temper and heat-treat various other steels and alloy metals to a higher scleroscope or Brinnell hardness, but stellite will outwear them at least three to one.

There is a vast difference between hardness and resistance to abrasion. Stellite is highly resistant to the actions of practically all commercial and industrial acids and suffers little or no loss in weight even after being in contact with these over long periods.

Stellite is non-magnetic and cannot be magnetized. The light reflecting power of the highly polished surface of stellite is only a little less than that of silver.

Because of its resistance to chemical action, it will take a high and lasting polish and retain it under very severe conditions. Stellite can be scratched only with difficulty.

A welder will become aware of one of stellite's most remarkable characteristics if he melts it under an oxy-acetylene blowpipe. He will be able to apply it to any grade of steel including carbon and alloy steels and practically any of cast iron and, without heat treatment, have a surface which still retains the original properties of stellite. Copper can also be stellite.

For the one particular purpose of welding, the metal is made up in the form of conventional welding rods. Though the welding of stellite calls for a slightly different technique than most oxy-acetylene welding, it can be done very easily after a few minutes of instruction and practice.

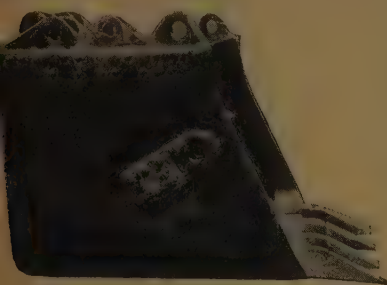
Stelliting, as the process is called, is neither welding nor brazing in the ordinary sense of the word. In welding the surface of the base metal is brought up to a flowing point, the steel welding rod then being puddled and fused with the molten base metal, when the bronze or brass is flowed on. The only bond is that which is obtained by the brass or bronze penetrating into the pores and holding.

Stelliting calls for a blowpipe flame which contains a fairly large excess of acetylene to lower the flame heat and to exclude as much atmospheric oxygen



STELLITING SAVES RENEWALS

as possible. The surface of the base metal to which the stellite is to be applied is brought up to such a heat that it just begins to sweat and assume an oily appearance. The lightest possible penetration into the parent metal is most desirable since this eliminates the possibility of an undesirable alloy being formed with the stellite.



NEW TEETH FOR THE SCOOP

At this point the stellite is melted from the rod and allowed to flow on to the base metal with as little agitation as possible. The action of stellite flowing on to the steel is similar to that of solder flowing from an iron on to an already tinned surface.

Examination of a stellite weld made in this manner shows that practically no penetration into or alloying with the base metal has occurred, and that the pores of the metal have not opened up and taken hold.

Stellite can be welded with the electric carbon or metallic arc process but the metal resulting from an oxy-acetylene weld is cleaner, less porous and unalloyed.

Let us consider the resistance of stellite to heat. Numerous manufacturing plants have production jobs in which they are forced to use a metal which is as highly resistant to heat as possible, especially the hot forming of sheet metal and the hot trimming of forgings. In hot forming sheet invariably a highly tempered die of carbon or alloy steel is used, the die being required to resist heat as well as abrasion. In very short time the heat of the forming operation will draw the temper to a point where the metal has begun to soften. When

this occurs, it is necessary to anneal the die and re-machine or grind and temper again; this procedure being carried through until the die is worn out and scrapped. Then it is necessary to make new dies.

Stellite is very desirable in applications of this type because it will resist the heat without losing any of its hardness. A die of machine steel or carbon steel is made up in the usual manner, and the wearing surface is left approximately three-sixteenths of an inch under size to allow for stelliting. After a die has been stellited and ground to size, it will stand up indefinitely under such an application. For instance, in the making of automobile crankshafts which are forged to a very close limit, a flash is left on the forging. It is necessary to trim off this flash while the metal is still hot. Various steels and alloys have been employed in the making of trimming dies for this operation. These sometimes trim as many as two thousand pieces before they need reworking; still they are inefficient as compared to a stellited die. It is necessary only to stellite the edge of a trimming die. When this is properly done, the die will stand up under as many as ten and twelve thousand operations before requiring reworking. It is then necessary



A NEW BEARING JOURNAL

only to return the die to the welder to be re-stellited and ground, no tempering being needed. Trimming dies of this type will give from four to six times the number of pieces that the best steels can give. The only time a stellited die ever approaches the scrap stage is when it is broken.

Other resistance to heat applications

are in the formation of dies for automobile spring clips, railroad anchors and numerous other fairly heavy steel sections which require hot forming or shaping.

The abrasion-resisting quality of stellite is a very pronounced one, the metal having three times the life of any other. In the Portland cement industry metal parts of pulverizing, grinding, crushing and conveying machinery are worn out in a very short time through abrasion or wear. These parts stellite acquire a great increase in life.

A screw conveyor of the conventional type stellite on the periphery is now outlasting heat-treated carbon steels six to one. A stellite surface one-eighth

metal as it is drawn. Many plants are now applying stellite-surfaced dies to these particular applications, and as a general rule they are getting from three to five times the life they formerly obtained from the best tool steels.

In the manufacture of dry cells or dry radio batteries a number of dies and machine parts come in contact with active chemical compounds which tend to corrode and destroy the metals used. Increase in life imparted by stellite is the result of its ability to resist this corrosion as well as abrasion. The majority of the stellite parts for this use are as a unit.

Stellite is used for homogenizing Diesel engine equipment, for chemical



HELICAL CONVEYORS DEMAND GREAT HARDNESS

inch thick on a gudgeon as used in the cement plant will give the part a life three times as long as one-half inch of steel.

Blades of exhaust heat fans such as are used in cement and various other industrial plants are cut down in a comparatively short time. By merely stelliteing their worn surfaces, a welder increases their life by four.

Hot drag chain supports, conveyor buckets and cams, steam shovel dipper teeth and roll mill plows are also stellite.

The combination of stellite's two properties, resistance to heat and resistance to abrasion, is seen in hot drawing and hot forming dies. The die is called upon to resist the heat of the metal being formed and the abrasion of this

compressors and for a great variety of other chemical equipment.

In the transmission of pictures by radio at the present time stellite reflectors and mirrors are being used extensively. These are far superior to anything else because of the facts that they have a high and lasting pitch and reflecting power, are not effected by atmospheric conditions and do not scratch easily. Some large telescopes and microscopes are now equipped with stellite reflectors and mirrors for the same reasons.

Stellite flowed on to steel or cast iron has the same properties as the original cast metal, the heat of the welding flame at no time robbing it of any of its properties.—A. V. Harris, of Haynes Stellite Company.

GASOLINE TAXES

Gasoline taxes collected in all States except New York, Illinois, Massachusetts and New Jersey, brought in a net revenue of \$187,603,231 in 1926, the Bureau of Public Roads has announced, following the collection of data from the various States. The bulk of the money was allocated for use in building and improving State highways.

The average rate of taxation was 2.38 cents per gallon. The highest tax rate was effective in Kentucky and in South Carolina, both of which charged at the rate of 5 cents per gallon. The lowest rate was 1 cent per gallon in Rhode Island and Texas.

Approximately 10,000,000 gallons of gasoline were consumed in the United States during the year, the tax reports indicate. In the forty-four States where a gasoline tax was collected 8,000,000,000 gallons of gasoline were consumed. Approximately 2,000,000,000 gallons were used in the other four States, it is estimated.

AVERAGE RATE IS \$2.38

The full text of a statement summarizing the net tax receipts and the rate of tax on December 31, 1926, issued by the Bureau of Public Roads follows:

Gasoline taxes yielded a net revenue of \$187,603,231 in 1926, according to data collected by the Bureau of Public Roads of the Department of Agriculture from the various States. A tax was imposed in all but four States at rates ranging from 1 to 5 cents per gallon, the average rate being 2.38 cents.

The tax collections indicate that nearly 8,000,000,000 gallons were consumed in the States imposing the tax and it is estimated that nearly 2,000,000,000 gallons were used in the four States in which no tax was imposed.

The revenue from the tax was allocated as follows: \$129,441,520 for State highways, \$42,609,479 for county and local roads, \$5,238,869 for payments on road bonds and \$9,313,363 for miscellaneous purposes.

Fewer changes were made in the rate

of tax than in other recent years. In Kentucky the rate was increased from 3 to 5 cents, in Mississippi from 3 to 4 cents, in North Dakota from 1 to 2 cents, and in Virginia from 3 to 4½ cents. Other increases which became effective after the close of the year were an increase in Alabama from 2 to 4 cents and in Montana from 2 to 3 cents.

	Receipts	Rate Cents
Alabama	\$2,558,651	2*
Arizona	978,264	3
Arkansas	3,585,304	4
California	16,502,123	2
Colorado	2,091,749	2
Connecticut	2,689,372	2
Delaware	390,414	2
Florida	11,431,486	4½
Georgia	5,653,140	3½
Idaho	1,122,217	3
Illinois		..
Indiana	8,971,741	3
Iowa	4,842,427	2
Kansas	4,303,388	2
Kentucky	4,935,078	5
Louisiana	2,708,667	2
Maryland	2,293,854	2
Maine	1,823,346	3
Massachusetts	2,293,854	2
Michigan	10,081,776	2
Minnesota	4,804,688	2
Mississippi	4,089,200	4
Missouri	5,661,145	2
Montana	870,712	2†
Nebraska	3,039,927	2
New Hampshire	768,582	2
New Jersey		..
New Mexico	762,851	3
New York		..
North Carolina	7,786,473	4
North Dakota	988,493	2
Ohio	13,257,266	2
Oklahoma	6,212,409	3
Oregon	3,333,829	3
Pennsylvania	11,781,782	2
Rhode Island	511,896	1
South Carolina	4,496,968	5
South Dakota	1,924,753	3
Tennessee	3,852,524	3
Texas	5,226,886	1
Utah	1,252,009	3½
Vermont	553,093	2
Virginia	5,855,670	4½
Washington	3,482,093	2
West Virginia	2,922,675	3½
Wisconsin	5,209,805	2
Wyoming	568,589	2½
District of Columbia	1,015,193	2
Total	\$187,603,231	Av. 2.38

* Changed to 4 cents on January 4, 1927.

† Changed to 3 cents on January 1, 1927.

—Courtesy of United States Daily.

PETROLEUM INDUSTRY

The supremacy of the United States in the petroleum industry is strikingly shown in a trade bulletin issued recently by the Minerals Section of the Department of Commerce. Seventy percent of the world's petroleum production, the bulletin reveals, is within our territorial limits. American refineries constitute the last word in mechanical equipment and efficiency in operation and their capacity far exceeds that of any other country.

Notwithstanding the fact that since the war many foreign countries have made strenuous endeavors to establish petroleum refining industries, few of them have attained any degree of success. The efforts of countries lacking domestic sources of crude petroleum, such as France, Germany and Australia, to build up what amounts to national refining industries have been to little purpose. For example, only one of France's eleven refineries is now operating and this one is unprofitable. Germany has apparently abandoned the idea of establishing a petroleum-refining industry and has turned to the "oil from coal" process, which is receiving intensive consideration from her scientists and engineers. Australia grants a large subsidy to its refining industry and has used every possible means to stimulate it but it still continues to be a drain on the Commonwealth's finances.

The experiences of these and other foreign countries, the bulletin points out, has proved the impossibility of building up a successful petroleum-refining industry in regions where there is no crude oil supply. Great Britain is an outstanding exception to this rule, but the British are in a different position from other nations in that they control a considerable supply of crude.

The post-war development of the refining industry in Great Britain has been remarkable and the development is still going on. It is estimated that approxi-

mately \$100,000,000 is invested in the industry, not including installations dealing with finished products. An idea of the growth of the British industry may be gained by a comparison of the statistics of crude oil imports, there being practically no domestic output of crude oil aside from that obtained from the distillation of shale. In 1913 only 31,700 barrels of crude were imported, while in 1925 the total receipts amounted to more than 16,000,000 barrels, or 500 times the pre-war figure, and imports for 1926 have been about the same as in 1925. The principal growth has taken place during the past six years, the first large increase having been in 1921 when nearly 3,000,000 barrels of crude were imported. Since that time there has been a steady and rapid increase, the 1925 figure being more than five times that of 1921.

Petroleum refining in the United Kingdom, the report states, is an outstanding example of the development of the industry in a country having no commercial production of crude petroleum of its own. It has developed, of course, because the United Kingdom is now the world's second largest petroleum-consuming country. In the case of the British industry, long-distance transportation of crude oil has been necessary. The bulk of the raw material has come from foreign countries, although chiefly from production under control of British companies.

According to the report, Rumania, Poland and Russia are about the only three European countries which are not more or less dependent on American refined petroleum products. All of these countries have plentiful supplies of crude and are therefore in a position to profitably refine. Mexico has a considerable number of modern refineries, two of which are among the largest in the world. Few of these Mexican refineries, however, are operating at full capacity.

—U. S. Department of Commerce.

FITCH

PIONEER STEAMBOAT BUILDER

The Hon. Ben Johnson of Kentucky, in a speech in the House of Representatives, gave the following résumé of John Fitch's claims:

Until recently virtually the whole world believed that Robert Fulton was the one who first applied steam to navigation. This belief grew out of the fact that in 1807 Fulton caused to be built and launched the steamboat *Clermont* on the Hudson River, to which event widespread publicity was given.

However, a few people in Connecticut, a few in Bucks County, Pa., a few at Philadelphia, and the people of the small town of Bardstown, in the State of Kentucky, knew that John Fitch built and successfully operated a steamboat of his own conception in 1785.

Fulton himself never claimed the distinction of being the inventor of the steamboat, and his biographer, Thurston, positively disclaims it for him.

Notwithstanding that fact and the many, many other facts which clearly show that Fitch, of Bardstown, Ky., did invent the steamboat, the schools of our country still are teaching the children that that distinction belongs to Fulton.

Not until 1915 did anyone succeed in gathering together in one paper the acts of the Legislatures of Pennsylvania, Connecticut, Delaware, Virginia, and even of New York, Fulton's own State, proving that Fitch was the inventor of the steamboat. Not until then had anyone also succeeded in locating the old, contemporaneous newspapers of Philadelphia and other places, giving descriptive accounts of the many, many trips of Fitch's boat on the Delaware River and other waters, more than twenty years previous to Fulton's boat, the *Clermont*.

Not until recently has attention been invited to the fact that the Congress of the United States granted a 14-year patent to Fitch nearly sixteen years before Fulton's boat made its appearance, and that George Washington, as Presi-

dent, signed the act of Congress granting the patent to Fitch.

All these facts now are buttressed by letters written by Washington, Jefferson, Patrick Henry, and other notables at the time in which Fitch and his steamboat are mentioned; and Fitch died nine years before Fulton built the *Clermont*.

About the year 1776 some of Fitch's friends left Pennsylvania and Virginia and went to and near the present site of Bardstown, Ky. Fitch followed them there in 1780. It seems from all that now can be gathered that he first located about six miles north of Bardstown.

In the court settlement of Colonel Isaac Cox's estate there is a paper signed by John Fitch, whereby he acknowledged payment of his charge for clearing some land for Colonel Cox. After having established his home at Bardstown and after having made successful trials of a small steamboat on a small local stream, he returned East, built larger boats, and operated them on larger waters.

The *Trenton Gazette* published an account of one of Fitch's first successful trips with his boat. He left Philadelphia for Burlington, twenty miles distant on this trip. The article in the *Gazette* says:

... Crowds of persons assembled at all the prominent points along the river to see her (the boat) pass, and waited for hours to witness what was then the greatest wonder of the day. At Point-no-point, now (then) Bridesburg, the whole population of Frankford and upper Philadelphia County were assembled; and they saw the boat slowly steam by them on her upward progress. Great, indeed, was their enthusiasm, and long and loudly did they cheer the grotesque exhibition. Women waved their handkerchiefs in approbation. Batteaux put off from shore and rowed alongside the steamer, cheering the adventurous and now exultant Fitch. . . .

The following facts, now not disputed, speak for themselves as to Fitch's conception and success of the steamboat:

April, 1785: While in Bucks County, Pa., conceived the idea of a steamboat.

September 27, 1785: Drawing of boat, models, and tube boiler presented to American Philosophical Society by Fitch.

November, 1785: Application made by Fitch to Virginia Legislature for encouragement.

November 16, 1785: Bond executed by Fitch to Patrick Henry, conditioned for the sale of maps to raise money with which to build a boat.

November 25, 1785: Thomas Jefferson gave Fitch a letter to Governor Smallwood of Maryland favoring a law to encourage Fitch in building a steamboat.

December, 1785: Fitch petitioned the Assembly of Pennsylvania for assistance in building a steamboat.

December 20, 1785: Advertised in *Maryland Gazette* for assistance in building a steamboat.

January 6, 1786: Petitioned the Assembly of Maryland for assistance.

January 19, 1786: The Assembly made a report favorable to Fitch, but gave no assistance on account of lack of funds.

March 18, 1786: New Jersey passed law giving Fitch fourteen years' exclusive right for boats propelled by steam.

April 17, 1786: Made working model of a steam engine with 1-inch cylinder.

July, 1786: Installed engine with 3-inch cylinder on small boat at Philadelphia.

September, 1786: Petitioned Assembly of Pennsylvania for a loan of £150 to aid in building a steamboat.

December, 1786: *Columbian Magazine* published drawings and description of Fitch's boat.

March 28, 1787: Pennsylvania Assembly passed law giving Fitch exclusive rights of navigation by steamboat.

February 3, 1787: Delaware Assembly passed a similar law for that State.

March 19, 1787: New York Legislature passed a similar law.

August 22, 1787: Fitch's boat, equipped with 12-inch cylinder, demonstrated at Philadelphia before the framers of the Constitution of the United States.

November 7, 1787: Virginia Assembly

passed law similar to that passed by New York, Delaware and Pennsylvania.

February, 1788: Petitioned Congress for help.

1791: Congress, upon favorable report made by Jefferson, Calhoun and General Knox, granted a patent to Fitch, and that was signed by George Washington as President.

As is shown herein, Doctor Thornton was a passenger on Fitch's boat in 1787. His certificate to that effect is on file in the Congressional Library at Washington.

Afterwards Thornton designed the United States Capitol at Washington.

In the very northeast corner of the Capitol Building, at the street door, is a fresco picture of Fulton looking out of a large window or from a balcony at a steamboat. His name is just beneath the picture.

On the opposite wall of the same room or corridor is a fresco picture of Fitch, dressed like a mechanic, at work making a boat. Fitch's name, too, is just beneath his picture.

As Thornton rode on Fitch's boat, and as he designed the Capitol, it is not at all improbable that he made provision for these two pictures in order to show to posterity the claim of Fitch as the real inventor.

Fitch spent the last days of his life at Bardstown, Ky. Of his inventions and disappointments during this period he wrote:

"I confess the thought of a steamboat, which first struck me by mere accident, about the middle of April, 1785, has hitherto been very unfortunate; the perplexities and embarrassments through which it has caused me to wade far exceed anything that the common cause of life ever presented to my view."

Mr. C. Seymour Bullock, in the *Connecticut Magazine*, said:

"Had Fitch been as thrifty as he was inventive he might have become wealthy, for Gardoque, the Spanish envoy to this country in 1796, wished to buy his invention for the sole and exclusive use of the King of Spain. Fitch replied, 'No; if there is any glory or profit in my invention, my countrymen shall have the whole of it.'"

In 1915 a bill was introduced in Congress asking for an appropriation with which to appropriately mark the grave of John Fitch at Bardstown, Ky.

But before action by Congress was taken our country became involved in the World War, and no absolutely unnecessary appropriations were made. Consequently the matter was allowed to

sleep. But at this Congress the matter was brought up again. The facts in the case were laid before the Members of both the Senate and the House; and each, by a unanimous vote, passed a measure appropriating \$15,000 for the purpose of appropriately marking Fitch's grave, and the monument has been recently fittingly unveiled.

BERTHELOT

DEVELOPER OF SYNTHETIC CHEMISTRY

American participation in a movement to create in Paris a memorial to Marcelin Berthelot, pioneer in the development of modern synthetic chemistry, has been actively agitated. In this connection Maurice Leon of New York spoke at a luncheon recently given by him at India House, to five members of the French delegation to the chemical conferences in Philadelphia and Washington. The guests of honor, who were about to sail for France, were Paul Sabatier and Gabriel Bertrand, members of the Institute of France, Pierre Belanger, Justin Dupont and Jean Voisin. Twenty-five men prominent in business and scientific circles were present, including representatives of French banking and other business houses.

"Just as every one knows Louis Pasteur," said Mr. Leon, "so should every one know Marcelin Berthelot, his successor as secretary for life of the French Academy of Sciences. Pasteur and Berthelot have influenced the fate of mankind more deeply than any other two men of modern times. The one gave to the world the modern science of bacteriology; the other the modern science of synthetic organic chemistry. Today their work in what seemed to be separate fields is being co-ordinated, and we learn of bacterial processes being utilized in the creation of new synthetic

organic chemical products of vast importance—solvents, fuels and explosives.

"I understand that leading scientists of Germany have expressed a desire to share in this project to bring about a fitting, permanent and effective tribute to the achievements of Marcelin Berthelot. This is as it should be for Germany owes much to him. But so does England, so does America. As a nation that owes to his genius so much that vitally affects all our activities—social, industrial, agricultural, and all that concerns national defense—we shall feel proud to be associated with you in the projected Marcelin Berthelot Institute."

M. Dupont, speaking for the French delegation, said that the proposed memorial would take the form of a building on the Boulevard des Invalides, in the shadow of Napoleon's tomb, the site having been donated by the French Government.

"In this house," he said, "it is our purpose to gather all published material bearing on the progress of synthetic organic chemistry in every part of the world. In such a centre the cause of research will be better promoted than is possible today, for everything which the memorial building shall provide will be open to all the world."—*New York Times*.

ETHER

October 16, 1927, marked the eighty-first anniversary of the first public use of ether for producing general insensibility to pain in a surgical operation. On that date in 1846, at the Massachusetts General Hospital in Boston, Dr. John Collins Warren operated upon a tumor of the jaw of Gilbert Abbott, who had been made unconscious by the fumes of ether administered by William Thomas Green Morton, a Boston dentist. The patient awoke from his sleep, having felt no pain, and several weeks later was discharged as cured.

The leading physicians of Boston were present; some had come in a skeptical mood, and when Morton's arrival was delayed they were sure that he did not dare face the trial of his announced marvel. At the conclusion of the operation the doubters were silenced by the remark of the operating surgeon, "Gentlemen, this is no humbug."

Morton was born at Charlton, Mass., August 18, 1819; died at New York City, July 15, 1868, a poor man; distressed also, in not having received due recognition for his important discovery. Practiced dentistry to make enough money to study medicine at Harvard, 1844-1846. He did not complete his studies; later Harvard gave him an honorary degree of M.D. for his achievement.

While practising dentistry he was deeply impressed with the amount of pain suffered by patients in connection with even minor operations. He studied all he could find upon the subject, and then made experiments with various substances upon insects and fish. Later he experimented upon his favorite dog, "Nig," whom he made completely unconscious without producing any harmful effects. After this he experimented upon himself. In his paper to the Paris Academy of Sciences, presented by the great chemist Michael Arago, he wrote: "Taking the tube and flask, I shut myself up in my room, seated myself in the operating chair, and commenced inhaling. I found the ether so strong that it partially suffocated me, but pro-

duced no decided effect. I then saturated my handkerchief and inhaled it from that. I looked at my watch and soon lost consciousness. As I recovered, I felt a numbness in my limbs, with a sensation like nightmare, and would have given the world for someone to come and arouse me. I thought for a moment I should die in that state and the world would only pity or ridicule my folly. At length I felt a slight tingling of the blood in the end of my third finger, and made an effort to touch it with my thumb, but without success. At a second effort, I touched it, but there seemed to be no sensation. I gradually raised by arm and pinched my thigh but I could see that sensation was imperfect. I attempted to rise from my chair, but fell back. Gradually, I regained power over my limbs and found that I had been insensible between seven and eight minutes. Delighted with the success of this experiment, I immediately announced the result to the persons employed in my establishment, and waited impatiently for someone upon whom I could make a fuller trial. Toward evening, a man residing in Boston came in, suffering great pain, and wishing to have a tooth extracted. He was afraid of the operation and asked if he could be mesmerized. I told him I had something better and saturating my handkerchief, gave it to him to inhale. He became unconscious almost immediately. It was dark, and Dr. Hayden held the lamp while I extracted a firmly-rooted bicuspid tooth. There was not much alteration in the pulse and no relaxing of the muscles. He recovered in a minute and knew nothing of what had been done for him. He remained for some time talking about the experiment. This was on September 30, 1846."

The words anesthetic and anesthesia were coined by Oliver Wendell Holmes, who spoke of the discovery as "this priceless gift to humanity."

Dr. Henry J. Bigelow, the great Boston surgeon, had been distressed not only by the suffering of his patients,

but also by the suffering of animals, upon which he had seen operations and experiments performed. He has often been quoted as opposed to animal experimentation, but after the development of anesthesia, he wrote:

"The dissection of an animal in a state of insensibility is no more to be criticized than is the abrupt killing of it, to which no one objects. The confounding of a painful vivisection and an experiment which does not cause pain—either because the animal is under ether, or because the experiment itself is painless, like those pertaining to the action of most drugs, or because it is a trivial one and gives little suffering—has done great damage to the cause of humanity, and has placed the opponent of vivisection at a great disadvantage. . . . A painless experiment on an animal is unobjectionable." (*Anesthesia: Addresses and Other Papers*, Boston, 1900, p. 371.)

The effect of the public demonstration by Morton and Warren was immediate. Within two days after the news reached London, ether began to be used in the extraction of teeth. Within a week it was used for more serious operations.

Dr. William H. Welch, head of the Johns Hopkins School of Public Health, said "surgical anesthesia has been America's greatest contribution to medicine and surgery."

The late Sir William Osler spoke of Morton as a "new Prometheus who gave a gift to the world as rich as that of fire, the greatest single gift ever made to suffering humanity."

In 1921 a marble bust of Morton was unveiled at the Hall of Fame of New York University and a memorial to him was unveiled at Charlton, Massachusetts, his birthplace, in September, 1924.—*Courtesy of American Association for Medical Progress*.

JOINTS SEALED BY PAINT

A paint which is said to be the only material that effectively seals joints against oil leaks has been developed by the General Electric Company and is sold by the Merchandise Department at Bridgeport, Connecticut. The product, known as G-E No. 880 Red Protective Paint, also prevents water and gas leaks. It can be used for many purposes which require red lead or white lead, and is less expensive than either.

The paint, which is dark red in color, requires no priming and can be applied by brushing or dipping. Denatured alcohol is used as a thinner. It dries rapidly and produces a hard, smooth, glossy film which is easily cleaned and

which prevents excessive collection of dirt and conducting material, thereby decreasing surface leakage and subsequent carbonization of the surface when used with electrical apparatus.

One of the first fields in which the paint has been applied is in the manufacture of fuel oil burners, in which one company is now using the material to seal all joints. Other fields in which there will be applications for the paint include plumbing, chemical plants, repair and service shops, packing houses, shipyards, central stations, electric railways, mines, and the manufacture of oil tanks, oil-burning locomotives and similar equipment.

PRIESTLEY

DISCOVERER OF OXYGEN

During the celebration of the golden jubilee of the American Chemical Society, founded in 1876, a pilgrimage was made to the grave of Joseph Priestley, eminent British chemist, philosopher and theologian, whose radical and unpopular views on religion and politics induced a mob to assault his home at Birmingham and led to his migration to America. He settled at Northumberland, Pa., in 1794, and died there in 1804. In 1774 he had discovered oxygen and had thus initiated the era of modern chemistry, although he remained a devotee of the old and outworn chemistry until his death. In 1874 the centennial of his epochal discovery of oxygen was celebrated at his hitherto neglected grave at Northumberland, and among the American chemists who gathered there contacts were established and friendships made which led to the founding of the American Chemical Society in 1876. There were 133 charter members, of whom J. B. F. Herreshoff, Charles E. Munroe, William H. Nichols and H. E. Niese survive. Two other members admitted in the first year, S. A. Goldschmidt and Adolph Kuttroff, are still members of the society.

For many years the membership remained small, being only a little over 200 in 1889, but since then the growth has been remarkable, so that the society is the greatest group of scientists in the world. Last year the most distinguished charter member, Charles F. Chandler, the best loved chemist of his time, passed away in his eighty-ninth year. Only a few months before his death he said he considered his share in the founding of the American Chemical Society as perhaps his greatest contribution to American chemistry.

At this fiftieth anniversary there was an award of the Priestley Medal to Dr. Edgar Fahs Smith, well loved of all American chemists and the grand old man of the University of Pennsylvania.

There was also a special award to Paul Sabatier of France and an address by him on "Modern Chemistry and Marcelin Berthelot."

Most of the few surviving members of the society and of those who attended the original Priestley Memorial meeting in 1874 attended the anniversary, as did many of the honorary members. Only fifty-eight of which have been named since the foundation of the society in 1876; thirty-six have died, two Germans were dropped during the war, and twenty illustrious names still remain, American, British, French, Belgian, Dutch, Swiss, Japanese, Canadian, Italian, Swedish, Danish and Czech, a glorious roll of honor of the world's truly great.

One of the most interesting personages was Prof. Charles E. Munroe, Dean Emeritus of the Faculty of George Washington University, famous explosives chemist and engineer, consultant to the Army and Navy Ordnance Boards and to other official organizations, and with Harvey Wiley and F. W. Clarke, one of the few survivors of the chemists present at the 1873 meeting of the American Association for the Advancement of Science at Portland, Maine, he is a charter member of the American Chemical Society. The previous year Prof. Munroe, who had just been elected an honorary member of the American Institute of Chemists, delivered the address introductory to the award of the Institute Medal to Dr. Blum of the Bureau of Standards.—*New York World*.

MICA

MINERAL OF A MYRIAD OF USES

The United States, world foremost in the use of electricity, depends largely on other countries for its supply of mica, which is used extensively in the electrical industries, according to the United States Bureau of Mines, Department of Commerce. India produces approximately 50 percent of the world's supply of sheet mica.

The growth of the electrical industries, together with the constant expansion in the use of electrical equipment by the public, has created an increasing interest in mica. Its unusual combination of physical properties, particularly its dielectric strength, resistance to heat, highly developed cleavage, transparency and flexibility, together with the ease with which it may be manufactured into finished parts, has caused mica to be considered an indispensable component in certain types of electrical equipment. Attempts to find satisfactory substitutes have been rewarded with limited success, and it is expected that the commercial importance of mica will increase in the future in proportion to the growth of the industries in which electricity is of prime importance. The remarkable development of the radio industry in the last few years has been dependent in part on the availability of high-grade mica. This market has consumed large quantities of the smaller-sized sheet material suitable for use in condensers.

The term "mica" is applied to a group of minerals which display great variation in chemical composition, although many of their physical properties are similar.

The varieties of mica are: Muscovite, called potash mica; phlogopite or magnesium mica; biotite or iron mica; lepidolite or lithium mica; roscoelite or vanadium mica; paragonite or sodium mica; zinnwaldite, and lepidomelane.

Muscovite and phlogopite are the micas of commerce. The other varieties of mica either are not available in sufficient quantities or do not possess the proper characteristics to attain industrial importance. Phlogopite is mined

in only two countries, Canada and Madagascar. Muscovite mica of commercial size is found only in deposits of pegmatite, which are similar to granite in mineralogical composition, but are characterized by coarse crystallization. The mica-bearing pegmatite is composed essentially of coarse grains of feldspar and quartz, accompanied by mica, the latter being present in masses known as "books" which vary greatly in size.

New Hampshire is now the leading producer of sheet mica in the United States. Until 1923, North Carolina held that position. It still is the largest producer of scrap mica. Mica is produced in small quantities in Alabama, Colorado, Connecticut, Georgia, Idaho, Maine, Nevada, New Mexico, South Carolina, South Dakota, Texas, and Virginia. In the past some of these states have been important producers and it is possible that future developments will result in an increased production from some areas.

The irregular structure of pegmatites has had a marked effect on the development of mica mines, for it has tended to make large systematic operations impossible. The likelihood that, as mining advances, the pegmatite formation may suddenly decrease in size or that the mica will cease to be present in paying quantities, increases the uncertainty of successful operation. The industry as a whole is characterized by numerous small operations, many of which are worked intermittently according to the price of mica or the leisure of the owner.

Sorting, cleaning, grading, trimming and cutting of mica are essentially hand processes, and little progress has been made in developing mechanical methods. The producing localities that have abundant cheap labor have a definite advantage, therefore, over regions where labor is high and scarce.

Mica may be briefly classified as sheet, splittings or scrap. Sheet mica is used principally for electrical purposes and for glazing, splittings are used for the

manufacture of built-up board, and scrap is ground to a powder.

Mica to be classified as sheet must yield a rectangle of at least one and one-half by two inches, must split evenly and freely, be free from cracks, rulings or plications, and be reasonably free from inclusions or strains of foreign matter. In order to be profitable, a deposit should yield at least a small percentage of sheets considerably larger in size than that given above. A high grade of mica is also required for spark plugs, particularly for those used in airplanes. Such mica must be very flexible so that it may be wound in small cylinders without cracking.

Its ability to withstand heat and its high electrical resistance has led to a wide application of sheet mica in the electrical industries. An important use of electrical mica is for inter-leaving between the copper segments of commutators. Thin films are used in vast numbers in condensers for magnetos and wireless apparatus.

As sheets in greatly diversified shapes, or as washers and tubes, mica is used extensively as an insulator in dynamos and in various fittings or appliances in fuse boxes, sockets, insulators, electric heaters, flat-irons, telephones, etc.

As a heat-resisting transparent medium, sheet mica has various uses. It was formerly widely employed for stove windows, but this use has declined to a considerable extent. Mica is also used in furnace sight-holes, heat screens, lamp chimneys, canopies and shades, particularly for gas mantles, also for military lanterns and in lantern slides.

Its ability to withstand shocks and strains, combined with its transparency, has led to the wide use of mica in motor goggles, spectacles, divers' helmets, smoke helmets, compass cards, gage fronts, and in windows subject to shock, as in the conning towers of warships. Owing to the resonance of mica, circular sheets of high-grade muscovite have been used extensively in phonographs, as sound-producing devices. Such sheets are used also in other sound-detecting instruments such as submarine detectors.

Among miscellaneous uses are its application for ornamental uses, particularly in India, as a dressing for wounds and as a substitute for canvas in portrait painting. A demand for very large sheets capable of supplying eighteen-inch circles has been noted. These large mica sheets are used as a base on which scenes are painted for projection upon the stage.

Mica splittings consist of thin flakes split from the smaller sheets or from waste fragments. They are used chiefly for the manufacture of built-up mica board. This built-up board is produced from alternate layers of splittings and shellac or other binder. The finished board is baked under pressure and machined to desired dimensions. Built-up mica is used chiefly for commutator segments, and in various forms in dynamos, motors, and transformers.

One of the largest uses of dry-ground mica is in the preparation of rolled roofing and asphalt shingles, where it is employed to prevent sticking between adjacent surfaces. Coarsely ground mica is used extensively for ornamental purposes, particularly for "Christmas tree snow," which is sold in considerable tonnages at holiday time. It is also used for the surfacing of stucco and concrete to imitate granite. Its use has also been reported for annealing steel, as a component of explosives, in calico printing, in paints and as an inert filler.

Wet-ground mica is in demand by the manufacturers of wallpaper for the decoration of papers where it is desired to bring out a lustrous pattern. Considerable ground mica is consumed in the manufacture of auto tires where it is employed as a lubricant. The hard-rubber industry also uses some ground mica. Mica mixed with greases is used in the preparation of special lubricants for metal bearings.

The dominant position of India in the mica industry is maintained by its large reserves of mica of good quality, and an unfailing supply of cheap labor. Mica is produced also in Canada, Madagascar, Union of South Africa, Rhodesia, Tanganyika Territory, Argentina, Brazil, and Guatemala.—U. S. Department of Commerce.

CHROMIUM

Chromium is one of the few essential metals of which this country does not produce supplies sufficient for its economic needs, the United States Bureau of Mines, Department of Commerce, points out. Although this country is by far the largest consumer of this metal, domestic production is now practically negligible, while imports in 1926 exceeded 200,000 tons. Chromium is used in the making of chromium steels which possess great hardness combined with toughness. The metal is also a constituent of rustless steel, stainless steel, and other special alloys. It is of great importance in the chemical industries and is extensively used as a refractory. The United States possesses large reserves of low-grade, high-cost chromite, which would be sufficient to meet domestic needs for six or seven years at the present rate of consumption, though a lowering of standard grades and a rise in price would both be necessary to bring about the mining of such reserves. Consumption and production of chromite in the United States clearly illustrate how an industry of considerable magnitude may depend entirely upon uncontrolled sources for its raw material. Chromite is but one of several metals—for example, manganese, tin and possibly mercury—that occupy a like position. In 1925 the United States required, to satisfy its trade demands, fully 60 percent of the world's production of chromite, 52 percent of that of tin, and 30 percent of that of antimony, although its production of each of these metals was negligible. It also required 25 percent of the world's production of mercury, although it produced but 10 percent, and 30 percent of the world's production of manganese, although it produced only 4.3 percent.

Chromium is commonly designated as a rare metal. Metallic chromium is crystalline and brittle, harder than glass, bluish-white in color, has a high metallic luster, and crystallizes in the cubic system. Chromium is not found as a native element, but generally as chromite, the only chromium mineral now used commercially.

The only method in commercial use for the reduction of metallic chromium is the thermit process, which is based on the reaction between aluminum and chromic oxide. For the grades of material demanded by the trade three distinct metallurgical methods are in use. These are: the smelting of chromite in the electric furnace to produce ferrochrome; the manufacture of chromates and bichromates by the chemical treatment of chromite; the production of metallite chromium, by extracting chromium oxide from chromite, and reducing this oxide to metal by the thermit process.

Ordinary chrome steel contains about 2 percent chromium. In the manufacture of chrome steels, ferrochrome must be used because of the metallurgical difficulties, which add to the cost of making these steels direct from chromiferous iron ore. Chrome steels can be bent cold, and can be welded to iron to form either a surface or a core that is extremely resistant to the attack of even the finest drilling tools. Chrome steels have many uses, including the manufacture of axles, springs, parts of gun carriages, automobiles, steel for safes, tires, cutlery steel, projectiles and armor plate. Steels intended to resist abrasive action are alloyed with vanadium, nickel, tungsten and manganese, in addition to chromium.

Rustless steel, commonly containing 13 to 14 percent chromium, is chiefly used in the manufacture of cutlery. An alloy known as stellite (essentially cobalt, chromium, and tungsten or molybdenum) is especially suitable for high-speed tools. Nichrome, an alloy of 60 percent nickel, 14 percent chromium and 15 percent iron, resists high temperatures and is used chiefly for annealing boxes and conveyor chains. Stainless steel, which contains 13 to 14 percent chromium, is used in the manufacture of exhaust valves, turbine blades, pump rods, rollers for bearings, in electric heating stoves, and in utensils.

Chromite is of great importance to the chemical industries. From it is obtained the chromium used for making

chromates and bichromates. Chrome pigments—yellow, green and red—are widely used. In the dye industry the soluble chromates and bichromates are used as mordants. They are also used in the tanning of chrome leathers, and in the bleaching of fats and oils. In the ceramic industry the chromic acids and the bichromates are used to color pottery. The United States imports annually considerable quantities of these compounds.

The most important use of chromite as a refractory is as a liner for the open-hearth steel furnace. From a study made by its metal section, the War Industries Board estimated that $2\frac{1}{2}$ pounds of chrome were utilized for every ton of steel manufactured. Chromite is used either as bricks or in irregular shapes as mined. Chrome bricks are used as a substitute for magnesite bricks, which are more costly.

Of the newer uses of chromium, one of the most interesting is for coating metals. In this country and abroad the electrolytic plating of various metals with chromium is now on a commercial basis. The coating is hard and white, resembling platinum; it resists the action of ammonia fumes, hydrogen sulphide, and nitric acid, and is not attacked by molten zinc, tin or brass. It is said that chromium adheres more closely to the metal on which it is placed than does nickel, and a brilliant finish can be obtained without polishing. It is being increasingly used for automobile finishing and for plating bearings. As chromium is not corroded by vegetable and fruit

acids, it may possibly supplant tin for some purposes. The research work that has been done on chromium alloys for resisting corrosion and high temperatures bids fair to revolutionize some of the older industrial processes and to make new ones possible.

For the manufacture of certain steels there is no known substitute for chromium. In tanning, also, no satisfactory substitute has been found. For pigments chromates may be replaced, but as a rule, to which the exceptions are few, the substitutes are more expensive. As a refractory in electric furnaces for making steel, chromium may be said to be interchangeable with magnesium. In steel furnaces operated at lower temperatures, chromite bricks may be replaced by magnesite bricks, but magnesite bricks are usually more expensive.

Present knowledge indicates that the world's major resources of chromite are in South Africa (Southern Rhodesia), New Caledonia, and western Asia Minor (Anatolia). In addition to the high-grade ore found in the countries mentioned, a large potential reserve of what is known as chromiferous iron ores is found in Cuba, Celebes, the Gold Coast and Greece. These chromiferous iron ores contain a fraction of 1 percent to 3 percent chromium, associated with a small percentage of nickel. The Cuban deposits in the district of Mayari have been estimated to contain upwards of 2,000,000,000 tons of such ore and those of the Celebes more than 1,400,000,000 tons.—*U. S. Dept. of Commerce.*

TAXES OF WAGE EARNERS

"Every income earner in the United States pays, on the average, at least \$350 per year in taxes of one sort or another—in other words about a dollar a day," states William Bennett Munro, professor of municipal government in Harvard University. "People who own property and earn large incomes are the ones who actually hand the collector his tax money, to be sure; but they merely give him, for the most part, money which they have collected from others. The owner of the apartment house collects taxes from his tenants in the form

of rent; the storekeeper collects taxes in the price of his goods; the lawyer and the doctor collect taxes when they charge fees. Taxes are an element in the cost of everything, an element just as certain as interest, wages, or profit.

"Taxes do not usually stay where they are levied. They are shifted from one shoulder to another until they finally reach someone, usually the ultimate consumer. The ultimate consumer, not the big business man, supports the government. Remember this when you vote increased taxes."

WASHINGTON MONUMENT

Probably no single "work of man" in this country inspires a deeper feeling of reverence than does Washington Monument. Those who have seen it once are impressed; but to those privileged to view it often its symmetry and simplicity make it almost holy.

Revered though it is today, Washington Monument, in the long interval between conception and consummation, passed in both its history and its structure successively from an auspicious start, through criticism and doubt, to delay and almost to abandonment, until by careful analysis and patient endeavor there was developed a broader, firmer basis whereon with confidence was permitted to rise a glorious success.

At the close of the Revolutionary War the Continental Congress, in 1783, desiring to honor Washington, authorized an equestrian statue to be erected at the place where the seat of Congress should be established. L'Enfant, in his plan for the city of Washington, provided for its location, but the statue was not built and it was not until fifty years later that a body of influential citizens of Washington caused themselves to be organized into the Washington National Monument Society and undertook to secure contributions for a suitable memorial of the Father of His Country.

In this way they were successful, to a degree, collecting approximately \$88,000. In 1848, having secured authorization from Congress, they made a start. The site indicated in L'Enfant's plan was at that time a marsh, but a mound only a few hundred feet distant proved alluring and, being selected, the corner stone was laid on July 4, 1848. In the meantime an imposing shaft instead of an equestrian statue had been decided upon.

Contributions of stones were solicited from societies, States, municipalities and individuals. Several stones bear inscriptions indicating that they were presented by the volunteer fire companies that existed then in almost all cities. One stone at the 60-foot landing bears the inscription "Presented by Anacostia Tribe, No. 3, I. O. R. M., D. C. on the 3d Sun

of the 3 x 7 Suns Worm Moon G. S. 5610." Another at the 90-foot level reads: "From the Mechanics of Raleigh, N. C." At the 190-foot landing are stones contributed by Turkey, Siam, Greece and other countries. Almost every State of both North and South sent its stony contribution.

The work had progressed slowly but surely until 1854 when an incident occurred that created much indignation and public discussion throughout the country. A stone which had been sent by the Pope was stolen, and no trace of it ever was found. So disturbing was this act of vandalism that the collection of public contributions ceased and with it construction work on the monument, which was then 150 feet high.

Not for twenty-two years, or until 1876, was work resumed and then it was to make a fresh start, beginning again literally at the very bottom. It had been decided to underpin the foundation, as even with height reduced from the anticipated 600 feet to a recommended height of 500 feet, the area of the foundation was considered insufficient to prevent excessive pressure on the soil.

The original foundation, 80 feet square at its base and 23 feet 4 inches deep, was composed of blue gneiss blocks of six to eight tons each, laid as rubble in mortar of hydraulic cement, stone, lime and sand. The new foundation was to consist of a concrete sub-foundation 13 feet 6 inches thick extending in under the old rubble for a distance of 18 feet and outside for 23 feet 3 inches, giving a total bearing surface of 16,000 square feet as compared with the original 6,400 square feet.

The undercutting necessitated the removal of 70 percent of the area of the earth upon which the monument was standing and was accomplished with a settlement of a little more than 2 inches at one of the corners, but without cracking or the opening of a joint in the 150 feet of completed shaft.

A second step in the strengthening of the foundation consisted of the removal

piecemeal of the flare of the original rubble foundation and the substitution of a still more flaring continuous concrete buttress. This buttress by careful manipulation was also made to extend somewhat inside the lines of the shaft, permitting the removal of almost exactly half the original foundation and, at the same time, more ideally transmitting the weight of the shaft to the new and larger base.

Like so many achievements of the civil engineer, this work, essential to the security and integrity of the thing of beauty that all who see admire, is hidden below ground and forgotten, and yet without it the other could not be.

Work was resumed on the shaft in 1880. Its final height is 555 feet $5\frac{3}{8}$ inches. The monument was dedicated in 1885 and opened to the public October 9, 1888.—*Society of Military Engineers.*

REMSEN

A FAMOUS EDUCATOR

Dr. Ira Remsen, President Emeritus of Johns Hopkins University, died at Carmel, Calif., March 5, 1897, after a brief illness at the age of 81.

Dr. Remsen, internationally known educator and chemist, had been honored by French and British societies for his work in chemistry. He founded the *American Chemical Journal* in 1879, and was its editor up to the time of his death.

A NATIVE OF NEW YORK

He was born in New York on February 10, 1846, and obtained his bachelor's degree at the College of the City of New York. Later he received an M. D. from the College of Physicians and Surgeons, Columbia University, and in 1870 the degree of Doctor of Philosophy at Goettingen, Prussia. The honorary degree of Doctor of Laws had been conferred by Columbia, Princeton, Yale, Toronto, Harvard and other universities. On April 5, 1875, Dr. Remsen married Mrs. Elizabeth H. Mallory of New York.

One of Dr. Remsen's last activities was as honorary Chairman of the National Committee in charge of raising funds for the Edward Curtis Franklin Fellowship in chemistry at Stanford University. Dr. Franklin was about to retire from the Stanford Faculty, and when his friends and students desired to honor him by raising \$10,000 or \$15,000 to found a fellowship in his honor, Dr. Remsen consented to help.

TAUGHT ONLY PURE CHEMISTRY

Though the author of textbooks on chemistry used in many colleges and schools, Dr. Remsen was above all things a teacher. On this primarily rests his fame. He never turned his hand to commercialize any of his studies, never took out a patent and never taught anything but pure chemistry. Few men, however, have had so great an influence in the sphere of applied chemistry. Perhaps the best known of his discoveries is saccharin. The actual finding was made by a student named Fahlberg, who was working under Dr. Remsen's direction.

Dr. Remsen had served in an advisory capacity to the Government and several large industries, but the years since his retirement in 1913 because of failing health were spent in travel and in revising his books.

MEMBER OF A FAMOUS GROUP

His death marks the passing of the last member of that illustrious group gathered by Daniel Coit Gilman in 1876 to form the original Faculty of Johns Hopkins University.

Then a Professor of Chemistry at Williams College, Dr. Remsen was called to Johns Hopkins, where he organized and headed the Department of Chemistry. From 1901 to 1913 he was President of the university, but continued to hold the chair in chemistry endowed by the late Bernard N. Baker in 1904.—*New York Times.*

HYDROGEN WELDING

Atomic hydrogen welding—the process by means of which hitherto unweldable metals can be melted and fused without the slightest trace of oxidation, and welding can be performed in some cases on metals as thin as the paper on which this is printed—is now made practicable by the use of equipment which is now placed on the market for general use. This process, making possible the welding of many special alloys and the production of ductile welds in iron and steel, is the result of research conducted by the General Electric laboratory.

In brief, this method utilizes the passage of a stream of hydrogen through the arc between two electrodes. The heat of the arc breaks up the hydrogen molecules into atoms. These combine again a short distance beyond the arc into molecules of the gas, and in so doing liberate an enormous amount of heat, so that more effective welding temperatures can be obtained than with the usual welding methods.

Since atomic hydrogen is a powerful reducing agent, it reduces any oxides which might otherwise form on the surface of the metal. Alloys containing chromium, aluminum, silicon or manganese can thus be welded without fluxes and without surface oxidation.

Thorough trials, extending over a period of many months, were made before introducing the new equipment. The apparatus, as finally designed, represents the result of continued experimentation and research.

The welding outfit consists of the following: (1) a single-phase transformer for converting the voltage of a 60-cycle source of power to one suitable for the welding equipment; (2) a specially designed, variable reactor to provide the proper welding current and voltage for different classes of work, and (3) the welding torch by means of which the actual work of welding is performed.

While the principle of operation is the same as that involved in the design announced as a laboratory attainment a year ago, the mechanical and electrical design has been much improved. The torch consists of a holder supporting

two tungsten wire electrodes, the electric conductors connecting these electrodes to the reactor and the tubing for the hydrogen gas. Each electrode is supported inside a nozzle through which the hydrogen gas is forced out around the electrode. The combination of electrodes and nozzles is set at an angle and the distance between electrodes, or arc length, and also the flow of gas, are readily adjustable.

The electric conductors to and through the torch are heavily insulated and, when welding ceases, the welding circuit is automatically interrupted until such time as the operator is ready to weld again, when the circuit is automatically restored. In contrast to the usual method of electric arc welding, there is no current flowing from the electrodes to the work to be welded. The circuit is completed from one electrode to the other.

The reactor consists of a "U"-shaped core provided with pole faces between which a pivoted armature is arranged to move. The legs of the core are provided with coils connected in series with the electrodes of the welding torch. The amount of welding current and voltage is governed by the movable armature which changes the air gap of the magnetic circuit and therefore the reactance. This armature is normally biased to an open position, and, upon a flow of current through the coils of the reactor, is attracted to a closed position that may be determined by means of a handle and a suitable mechanism. When the arc is struck the armature automatically assumes the closed position and remains there until welding ceases, when it automatically resumes the normal position of maximum air gap.

In making edge welds, the metal to be welded is melted under the heat of the arc but, when it is necessary to add additional metal, a filler rod must be used and fed into the arc in much the same manner as is followed in the ordinary gas welding process.

The new equipment is so far being marketed for operation from sixty-cycle, single-phase circuits only, and is recom-

mended for use on ordinary metals of less than one-quarter inch in thickness, or on hitherto unweldable metals of greater thickness. Metals having a thickness of but ten mils can easily be welded and little doubt is expressed that, in some cases, work as thin as two mils (about the thickness of ordinary writing paper) can be welded.

Because of the absence of oxides and nitrides from the weld made by this process, it is particularly adaptable to

the welding of special alloys so far not weldable by other methods, and also makes a strong, smooth and ductile weld on ordinary iron and steel work. Inasmuch as pure chromium, nickel, copper, aluminum, silver and other metals and their alloys—not to mention iron and the more common metals—can be melted without oxidation, it is expected that new possibilities will be opened in such welding, although the field of application has been but partially studied.

ABEL

ISOLATOR OF ADRENALIN AND INSULIN

Without pecuniary advantage to himself, he has done more than any other living American scientist to promote human enjoyment of life.

A slight blush of embarrassment colors the lean face of the kindly old man who steps up to receive one of the greatest honors the world of science has to bestow—the Willard Gibbs Medal awarded by the American Chemical Society in recognition of a scientist's work as a great benefactor of mankind.

The gold medal carries with it only a slight financial reward, in comparison with the value of great work done by its recipient. But the award is an honor cherished far more than money.

Thus does Dr. John J. Abel, head of the department of pharmacology of Johns Hopkins University, go down in the annals of science as one of the greatest in history. For it has been through his persistent efforts that mankind is being relieved of many ills. His name will be mentioned with Osler and Pasteur, men who have advanced science over tremendous gaps.

Yet Abel, like Pasteur, is not a physician. His is the science of drugs. He is a chemist, biologist and physicist combined, but as such he has done invaluable good to medicine. He has helped medicine be more certain of itself, by his long and extended experimentation.

At seventy, for he was born at Cleveland, Ohio, May 17, 1857, he sees his con-

tributions to medicine applied throughout the civilized world. But he is not through. He is still active, refusing to forsake his chemical laboratory, where his search is directed toward another benefit to mankind.

Now Dr. Abel is best known for isolating adrenalin from ductless glands.

Adrenalin is necessary to human life. Crude extracts of it are known to have curative value. Isolated, it was found to be a drug that fortifies the heart.

Although this "principle" was isolated thirty years ago, he refused to stop. He studied the human extract until he discovered its complex composition, and then he proceeded to duplicate it for commercial and quantity production. This he has done and now adrenalin is a commercial drug whose base is epinephrin, supplied as glandular extract from packing houses.

Now, despite his completed span of life, he is pursuing the mysteries of insulin, another gland product discovered by Drs. Banting and Macleod of Toronto as treatment for diabetes. He has already isolated insulin in the form of a chemically pure crystal, after two years of patient research.

The Willard Gibbs Medal is only the latest of many honors bestowed on this scientist. Besides his medical and arts degrees he holds honorary degrees awarded at five different times.—*Israel Klein in New York Telegram.*

MANGANESE

The United States, by far the largest producer of iron and steel, depends almost wholly upon foreign countries for the manganese which is an essential in the industry, according to the United States Bureau of Mines, Department of Commerce. In 1925, the last year for which figures are available, 890,428 tons of high-grade manganese ore were used in the United States, 615,000 tons being imported during the year. The United States uses approximately 35 percent of the world's annual output of high-grade manganese ores, but its contribution to that output is only 4 percent. More than 92 percent of the manganese now utilized goes into the manufacture of steel.

Manganese belongs to that group of elements which includes iron, cobalt, and nickel, states J. W. Furness, mining engineer, Bureau of Mines, in a report just issued. It is never found in the metallic state in nature, but generally occurs as oxide, silicate, or carbonate. Manganese is a crystalline, brittle metal, silvery white or grayish-white in color with a reddish luster.

Under present practice, manganese is essential in the steel industry. For many of the minor uses of manganese there are substitutes. Manganese is a constituent in various alloys, including ferromanganese, spiegeleisen, manganese bronze, silver bronze, and silicospiegel. It is used as an oxidizer in dry batteries; the decolorizing of glass; the drying of varnishes and paints; in the preparation of oxygen; and the manufacture of disinfectants. It is used as a coloring material in glass, pottery, tiles and brick, in calico printing and dyeing, and in certain paints.

Manganese in manganese steel ranges from 12 to 40 percent. The wide variation is due to the large differences in the properties imparted to steel by slight changes of manganese content. Manganese steels are hard without being brittle, and are malleable although difficult to machine. Two classes of articles are manufactured from these steels: Those that must offer great resistance to abrasion, either by friction against smooth,

hard surfaces, or against hard, brittle and angular materials; and those that must resist strains due to shock accompanying abrasion. Articles now commonly made of manganese steel are: Gears, pinions, sprockets, chains, dies, liners, wearing plates, rolls and rollers, railroad frogs and switches, and the crushing faces and digging parts of crushing and pulverizing machinery, such as plates, dies, rollers, and stamp-mill shoes. For making some of these articles manganese steel is practically the only alloy available, but for making others it is no more desirable than some other alloys, such as those of chromium, vanadium and tungsten, with which it must compete at current prices.

The chemical properties of manganese, which put it in a class by itself in the manufacture of steel, are as follows: Preventing over-oxidation of the steel by eliminating the oxygen in the bath (deoxidation); eliminating of sulphur from the bath (desulphurization in the sense of reducing the sulphur to a form unharmed); retarding the formation of blowholes; rendering the slag fluid; and adding the requisite amount of manganese desired in the finished steel.

The world at present depends upon four great sources for its manganese: Russia, India, Brazil and the Gold Coast. In 1925 the world's production was approximately 2,570,000 tons, of which Russia produced 32 percent, India 24 percent, Brazil 12 percent and the Gold Coast 13 percent. The Tchiaturi deposit, in the Province of Kutais, Republic of Georgia, south of the Caucasus, may be classed as the largest single deposit of manganese ores now known. It covers some 22 square miles, and estimates of the total commercial ore range from 44,000,000 to 200,000,000 tons.

In the United States the production of manganese, except during a few years prior to the advent of the Bessemer and open-hearth processes for making steel, has never been able to satisfy the domestic demand. The occurrences of manganese in this country are, broadly speaking, well known, and if the past history of mining of this metal is taken

to indicate the trend of the future, the United States does not possess a supply that can meet its demands. Unless methods are evolved for beneficiating low-grade manganiferous ores this country must remain dependent upon foreign sources as long as manganese is required in the manufacture of steel. Mining of manganese in the United States began in 1832 at the Paddy Run mine, Frederick County, Virginia, and during the first few years of its operation some 5,000 tons of high-grade ore were shipped to England. During the years 1885 to 1890, inclusive, the Crimora mine of Augusta County, Virginia,

supplied a large part of the needs of the Carnegie Steel Company. Since 1890 the domestic production has ranged from a fraction of 1 percent of the domestic needs to some 32 percent during the war years of 1917 and 1918. The ores produced during these years were mixed with high-grade imported ores in order to render them usable. And their utilization was made possible only by modification of peace-time specifications. Except for the chemical ores produced in the Philipsburg district of Montana, the supply of high-grade metallurgical manganese ores in the United States is meager.—*U. S. Dept. of Commerce.*

ONNES

FAMED FOR LIQUEFYING HELIUM

Heike Kamerlingh Onnes was born in 1853 at Groningen, Holland, and educated at the university there. After being assistant at the Delft Polytechnic for a time he became professor of physics at Leyden and from 1883 on made researches on low temperatures.

In 1905 he began to study helium, which he prepared from monazite. Three years after his studies began he succeeded in liquefying helium, ascertaining its boiling point, density and critical temperature.

In an unsuccessful attempt in 1923 to solidify helium he produced the lowest temperature ever recorded by man, 272.18 below zero, Centigrade, or about 458 degrees below zero, Fahrenheit. The absolute zero, denoting the entire absence of heat, is 273 degrees below zero, Centigrade, or, expressed in scientific language, the temperature at which there is no atomic or molecular motion.

Every gas has been solidified except helium. In the final experiment of Dr. Onnes he evaporated liquid helium in the most perfect vacuum obtainable,

producing the vacuum in it by the use of a battery of twelve glass and six iron, Langmuir vacuum pumps connected in parallel. His pumps left a pressure of only one-65,000th of an atmosphere.

In his experiments to reduce resistance to electric current, Dr. Onnes found that the resistance apparently disappears if the metals are reduced to the temperature of liquid helium. His apparatus consisted of a coil of lead wire with the ends joined immersed in liquid helium. The current of half an ampere was started in the coil by induction and continued to circulate for four and a half hours without losing strength. Scientists said when the discovery was announced that if it could be applied to industrial power units it would save enormous sums.

He received the Nobel Prize for Physics in 1913.

At the time of his death, February 21, 1926, he was emeritus professor and director of the physical laboratory at the University of Leyden.

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